

# *PROCEEDINGS*

**4<sup>th</sup> International Congress on**

*“Science and Technology for the  
Safeguard of Cultural Heritage in the  
Mediterranean Basin”*

***VOL. I***



**Cairo, Egypt**  
**6<sup>th</sup> – 8<sup>th</sup> December 2009**

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VOL. I

*Sessions: A, C, D*

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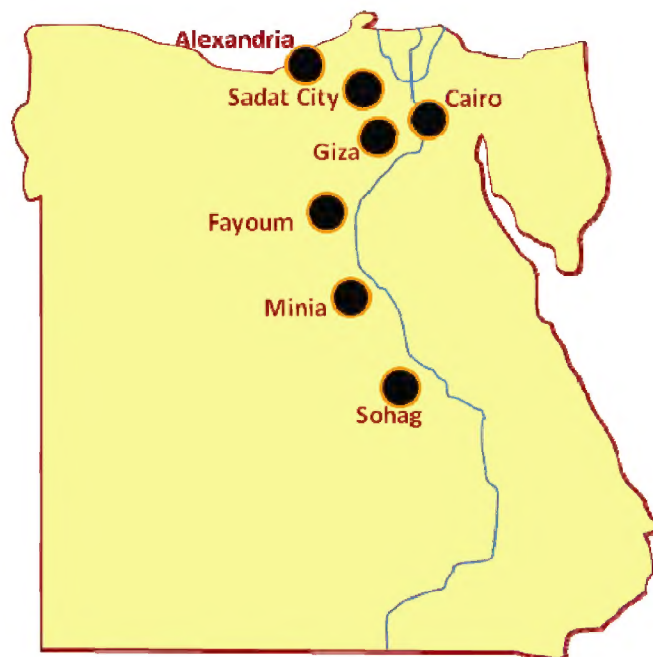
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**Delegates come from:**



**Egyptian Universities Delegates**



## Italian Universities Delegates



## Italian Scientific Institutions Delegates



# Facts and Figures

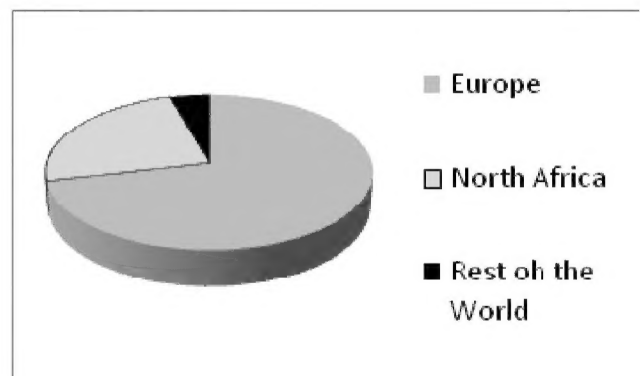
- 24 Countries represented (\*)
- 353 Delegates
- 246 Oral presentations
- 52 Poster presentations
- 1 Panel: EACH

(\*) *Algeria, Austria, Belgium, Bulgaria, Canada, Croatia, Egypt, France, Germany, Greece, Hungary, Indonesia, Iran, Italy, Japan, Kenya, Morocco, Nigeria, Pakistan, Slovenia, Spain, Tunisia, Turkey, UK.*

## Profile of Delegates

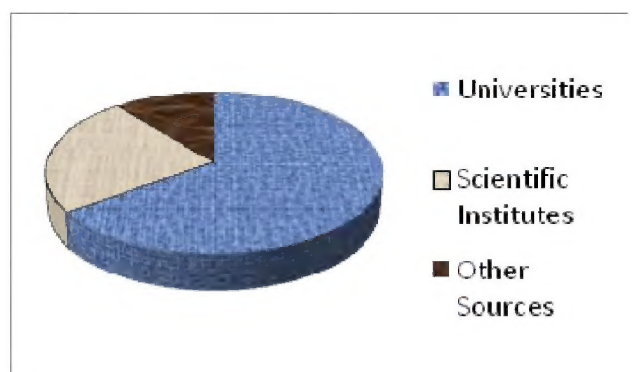
### By Regions

- Europe: 254
- North Africa: 85
- Rest of the world: 14



### By Institutions

- Universities: 230
- Scientific Institutes: 84
- Other Sources: 39







## اهلا وسهلا! WELCOME!

It is well known that the countries facing the Mediterranean Sea are considered the cradle of our civilization. Evidence of this statement is the impressive number of monuments and works of art of every kind distributed throughout these countries.

Unfortunately, the cultural heritage decays constantly; the safeguard of this heritage is fundamental for the preservation of the roots of our culture. Scientists can play a significant role to achieve this purpose.

The major objective of this Congress is to establish the “*state of art*” of science and technology for the safeguard of cultural heritage in the countries of the Mediterranean basin, by encouraging international exchange of information among scientists, with the fundamental purpose of helping public Authorities to preserve and exploit cultural heritage.

Another major problem to be debate stems from the cultural restoration and revitalization of the historical centres of many cities facing the Mediterranean Sea. Every effort should be made to convince populations and public Authorities to consider these centres an impressive cultural heritage for present and futures generations.

But not only that: because the Congress will also be the place for a comparison of how all the performing arts are conceived and exploited in Europe and in Africa: dance, theater, cinema will be main topics to be studied,

particularly the strong impact of information technology on these arts.

This time the Congress is held in Cairo, which means in Arabic “*the Victorious*”, and is the center of the Arab culture; it is the largest city all over the Middle East and it is the center where many cultures met since thousand years, as shown by its magnificent monuments, from the Wonders of the World like the pyramids, to the magnificent Islamic and Christian temples.

This “*melting pot*” of different cultures is one of the best places where to discuss the “*state of art*” of the sciences and technologies necessary to preserve for the Humanity its fundamental patrimony and it is also the right place where to discuss of what do we expect from globalization and how this world change may influence the true basis of our identities.

For these reasons we invite you to attend this Congress; you will certainly enjoy its scientific programme, as well as its social and excursion programmes, visiting one of the best places the world over for cultured people.

Welcome to Cairo!





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Mevlevi couvent and garden



South-East façade from garden



Interior view looking towards north-west Iwan of Madrasa



Mevlevi Complex from east



## Sponsors and Organizing Committee

### *Italian Institute of Culture, Cairo*

This prestigious Institute supports cultural events allowing Egyptian people to meet Italian artists and scientists; these exchanges contribute to the development of reciprocal friendship and cultural rise.

*Italian Embassy, Cairo*

### *Supreme Council of Antiquities, Egypt*

The fundamental Egyptian Partner for this event, a world famous Institute. The



Council, (commonly abbreviated SCA) is part of the Egyptian Ministry of Culture and is responsible for the conservation, protection and regulation of all antiquities and archaeological excavations

in Egypt

*Zahi Hawass*

*Director of the Supreme Council of Antiquities, Egypt*

### *Fondazione Roma – Mediterraneo, Italy*



This Foundation is a well known Italian Institution of bank origin which supports many cultural activities like a prestigious Museum in Rome and is also developing cultural initiatives in European countries facing the

Mediterranean Sea

*Emmanuele F. M. Emanuele*

*President of the Fondazione Roma – Mediterraneo, Italy.*

### *Ministry of Cultural Heritage, Italy*

This public Institution takes care of the Italian Cultural Patrimony.

### *Ministry of University & Research, Italy*

This public Institution takes care of the Italian activities of Universities and scientific Institutes

### *Ministry of Culture, Egypt*

### *UNESCO, Cairo Office, Egypt*

A world famous ONU cultural Institution, a fundamental Partner which will contribute to the success of this event

### *EACH Project - AIC (Association Investing in Culture), Italy*

The same team of scientists who organized the previous three Congresses.

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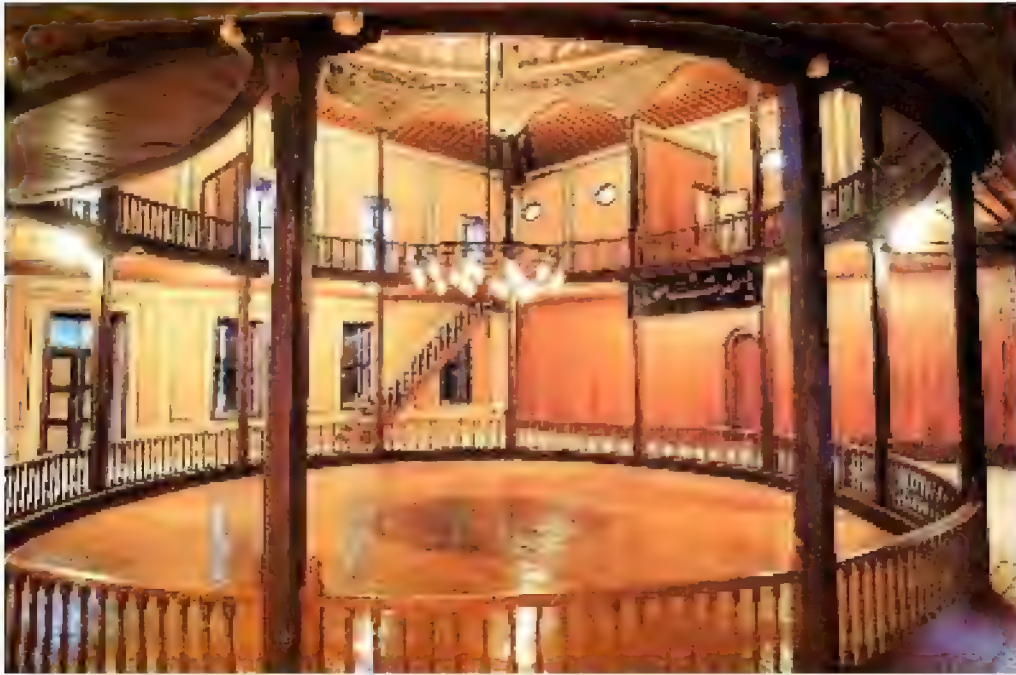
Società Geografica Italiana

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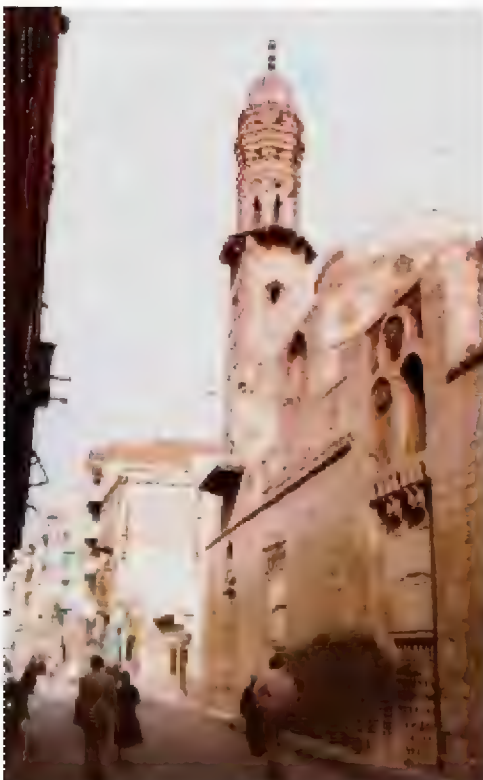
An Italian onlus Association working in Africa and Middle East on Cultural Heritage restoration.



## THE CONGRESS LOCATION



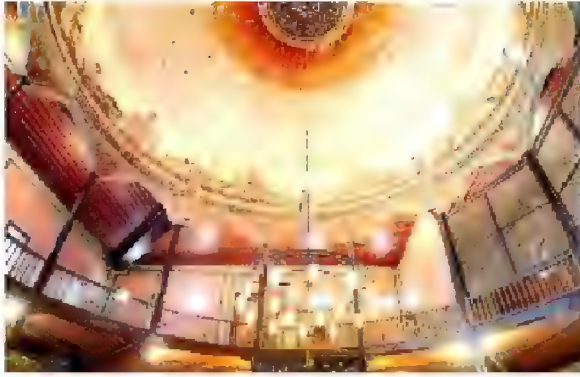
**Sama' Khana Theater**



The architectural Complex of the Mawlawi Dervishes is located at the foot of the Citadel. These buildings cover a vast area as shown by the following map. Their entrance is on Shari' al Suyufiyya.

The Mawlawi Dervishes described as “whirling dancers” according to their rite originated in Turkey, motherhouse in Konya. They moved in a circular dance in a anti-clockwise direction. All the buildings, cells, madrasas and gardens of the Complex were related to their activity.





**Sama' Khana Theater**



**Derwish whirling Dancers**

Under the theater area, there is a vast museum containing what has been found during many years of work to restore the whole Complex.

(See website <http://www.cfpr.it> )



**Khana Museum**



**Khana Museum**



Opening Ceremony: UNESCO, ICCROM, Italian Embassy, SCA, CIERA, CULTNAT, SGI, Foundation Roma-Mediterraneo, etc.





Delegates of the Congress



Sama' Khana



## SCIENTIFIC PROGRAMME

### SESSION A

#### ENCOUNTER OF CULTURES; HISTORICAL CITIES

- A.1 – Identity and globalization
- A.2 – Reuse of historical Centers
- A.3 – Seismic emergencies
- A.4– Geographic Information Systems related to archaeology

### SESSION B

#### METHODOLOGIES AND MEASUREMENTS

- B.1– Evaluation of damage: restoration and conservation of mobile Cultural Heritage
- B.2 – Evaluation of damage: restoration and conservation of monuments, buildings and historical gardens.
- B.3 – Evaluation of damage: restoration and conservation of paper, parchment, etc.

### SESSION C

#### LIFE SCIENCES; PERFORMING ARTS

- C.1 – Genetics, etno anthropological heritage: Peopling continuity in Europe and in the Mediterranean Basin
- C. 2 – Cinema, photography, dance: continuity in Europe and in the Mediterranean Basin

### SESSION D

#### MUSEUMS AND TOURISM

- D.1 – Museum Projects, virtual Museums
- D.2 – Microclimate inside Museums
- D.3– Tourism & economic exploitation





# OLD PROBLEMS, NEW CHALLENGES

ANGELO GUARINO

AIC Each Project - Rome

## 1 - The choice

The choice of Cairo for this Congress is a strong recognition of the important role Egyptian scientists play nowadays in the field of restoration of the cultural patrimony of Humanity.

A patrimony continuously under attack for natural disasters like earthquakes and floods, and for human disasters like fire and wars.

To preserve our patrimony we need a wide involvement of actors, private and public subjects, resources and energies which go well beyond the sphere of state actions and finances.

To preserve our patrimony we need to behave as a community, to elaborate innovative strategies, to experiment new tools and new methods.

This Congress is the right place for starting this action. A new common plan must emerge from dialogue and collaboration among all of us.

Unfortunately, important unexpected occurrences prevented our major invited sponsors to be present this morning at the Opening Ceremony, prof. Zaki Hawass Director of the Supreme Council of Antiquities of Egypt and prof. Emmanuele F. M. Emanuele President of the Fondazione Roma-Mediterraneo. Both of them invited me to welcome you.

Let me also thank in advance prof. G. Fanfoni for putting at our disposal this magnificent Sama' Khana Complex and the UNESCO Officials and in particular Prof. G. De Puymège and Dr. C. De Simone for their strong help in realizing the Congress.

## 2 – Our common future: globalization?

To begin with, let us start with an apparently stupid question: what does it mean Cultural Heritage?

The usual answer is: ***"Every object of historical and artistic interest"***.

However such an answer is a rather poor definition because it stresses our Heritage in art objects like paintings, statues and historical buildings but ignores other significant matters like our biological Heritage.

In fact, this definition would scarcely have given dignity of Cultural Heritage to studies on a human skeleton: but these studies are crucial to give, for instance, answers in epidemiological researches.

A better definition is ***"Cultural heritage represents every material evidence of the cultural identity of a population."***

Cultural heritage represents the cultural roots of the Identity of a population like in a tree the branches, the flowers, the fruits stand up and draw their lymph from the roots.

Cultural heritage defines the diversity existing among our populations. Thanks to this diversity the Mediterranean Basin is one of the best centre of civilisation of our planet

The preservation of identity has always been a crucial point, yesterday as well as today, for all governments and populations.

Unfortunately, there is nowadays all over the world a trend toward the loss of cultural identities. The danger comes from many sides but mass media are particularly efficient, even if people simply are not aware of it. Television, Internet, mobile telephones and smartphones are preparing a "global village", which actually should be better defined as a "global colony" in the hands of multinational economic groups which simply have no interest at all in preserving national identities: they want simply make money!

Apparently, nobody cares about cultural identities which seem simple philosophical disputes.

By consequence, we may agree on one point: our national cultural identities are in danger and will be wiped out in a few decades.

But the need to preserve identities has been always a problem: I want to refer to you an episode of ninety years ago.

Ninety years ago, in 1919, at the Peace Conference after the first World War, the Saudi Arabia Prince Faysal said, and I want to use exactly his words: ***"We ask you not to impose your civilization, but to help us to choose what is in our interest"***

في مؤتمر السلام قال الامير فيصل الكلمات التالية  
"نطلب منكم الا تفرصوا علينا حضارتكم ككم بل ان تساعدونا علي اختيار ما يخدم مصالحنا"

But once defined what is Cultural Heritage, a second question arises: ***"Why should we all bother safeguarding this Heritage?"***

In other words: why should we spend significant human and financial resources on that, subtracting resources necessary to face other major problems like poverty and unemployment?

There are people who strongly believe that it is a moral duty for the whole mankind, a “kategorische Imperativ” to use the words of Kant, with no interest whatsoever except leaving our Cultural Heritage to future generations.

There are other people who believe that safeguarding Cultural Heritage has to be done just for the pleasure of enjoying life: this belief is probably at the roots of tourism and in fact, tourism may help to generate new jobs and to develop new infrastructures like roads, hotels, houses, all over Europe, Africa and Middle East.

Both opinions are probably right and represent different sides of the same truth: the safeguard of our Cultural Heritage is a “must” for our societies. Whichever is our opinion, we may conclude that the preservation and conservation of our cultural heritage is crucial for the simple survival of our cultural identities.

But such an action is quite delicate because we risk to divide cultural heritage between rich and famous art works and poor and unknown art works.

For a government a famous monument is important because tourists come from all over the world to visit it. But probably for the citizen of the same country that specific monument does not mean anything. In other words, a government tend to take care only of the monuments which bring tourists and will ignore other monuments more meaningful for the common citizens.

So, we should be very careful making lists of monuments.

Sometimes these lists are bizarre; for instance, in U.K. in Leicester, in the 1880's some citizens asked that the ancient Tower of the Guildhall (Hotel de Ville) be demolished because it spoiled the view of the chimneys of a new factory built in those years. Happily enough they were not satisfied.

Nowadays, the Leicester Guildhall Tower is still there protected by the British List of monuments as a first class building: and, ironically, also the factory built in the 1880's is protected by the same list: but as a second class building!

In any case, Cultural Heritage is a vital source of money for all the countries around the Mediterranean Basin.

Impressive figure!

In 2008, on 922 million tourist arrivals all over the world, 53% concerned Europe, 18.2% Middle East, 4% North Africa. Practically one half of the world tourists visited Europe.

In Middle East, Egypt was the most visited Country, with about 12 million arrivals in 2008. The estimated income has been of 18.2 billion US dollars, or 16.3% of the Egyptian GDP. In the next future it is estimated a further increase, particularly in the areas of the Red Sea and the Mediterranean coast, particularly with investments from the Gulf neighbours with an estimated increase of rooms capacity up to 240.000 rooms by 2011.

However, behind these impressive figures, we observe that phenomenon of the two markets, the cultural tourism and the so called “sunshine” tourism are beginning to diverge. In other words, the “new” sunshine tourists are uninterested to Egypt's cultural treasures. We may easily imagine which could be the consequence for the next decades: a sunshine tourist goes where he gets better services at lower cost, and any place on our planet is O.K. provided it can be easily reached by low cost flights. If this phenomenon increases we all will loose tourists and income in the next future!

So, in order to preserve this vital sector of our economies we need to convince our European citizens that visiting the cultural patrimony around the Mediterranean Basin is a must to complete their education, a way to enjoy “personally” and not virtually the places where their civilization started, and of course, to take also baths on a sunny beach!

### **3 – Our common past: the broken memory**

We often listen that the Mediterranean Basin is the cradle of our civilization. Right!

But we cannot forget that the Mediterranean Basin was also theatre of struggles and cruelties of any kind in the past.

We have to overcome all that!

When I say that we have a “broken memory” behind us, particularly in Europe. I mean that a piece of our common civilization has been removed from our culture. For instance, European children read in their school books pages and pages on Greek and Latin heritage, on their literature, their philosophy, their history, but just very few aspects of the Arab culture of the past and present. Please, mind that we are not talking of Chinese or Japanese cultures, but of a culture which grew up on the same Mediterranean Basin; a culture that stayed just inside Europe, like it happened for Spain and Italy for hundreds of years.

We have a problem; a problem of what I call a “broken memory”

We named the halls where you will present your works with the names of illustrious Arabs, in particular of the philosopher Averroes and the poet Abu Nuass. But there is a hall dedicated to another poet that probably you never heard of: Bellanubi. His full name was .’Ali Al Bellanubi: he was an Italian poet born in Sicily by parents who lived for generation in Sicily. He died in Cairo after the Norman invasion of Sicily.

He wrote some flamboyant poems remembering the place where he was born, like this poem:

*“ Rejoice the oranges you take,  
Their presence gives you joy.  
Welcome the stars on the trees  
Welcome the cheeks on the branches,  
It seems like sky poured gold  
And land generated pomes.”*

Sorry for my poor translation, but I am no poet!

But there is a reason why I read this poem; similar verses were written many centuries later by another poet, Wolfgang Goethe:

***Kennst du das Land, wo die Zitronen blühn?***

***Im dunklen Laub die Goldorangen glühn,***

***Ein sanfter Wind vom blauen Himmel weht,***

***Kennst du es wohl? Dahin!***

***Dahin möcht ich mit dir, o mein Geliebter, ziehn!***

Everybody knows this poem; but how many people know even the simple existence of ‘Ali Bellanubi?

But also this Sicilian poet belongs to our identity, and his poem to our Cultural Heritage; I guess you now realize what I am trying to say with the idea of a “broken memory” concerning our past culture.

A second example which happened just one week ago, 25<sup>th</sup> of November.

The Spanish Parliament decided to express its regret for the expulsion of moriscos from Spain four hundred years ago.

***“El PSOE pide perdón a los moriscos por su expulsión en el siglo XVII”***

***La proposición establece .....que la expulsión de los moriscos, firmada por el Rey Felipe III el 9 de abril de 1609, fue una "tragedia en toda la Península" y que "conocer qué ocurrió con esa población es un ejercicio de memoria histórica".***

#### **4 – Science and enterprise**

But once we do our best to save identities by preserving our cultural patrimony, another fundamental question arises: ***“Which is the role of science?”***

The answer to this question is the main reason for being here today.

The commitment of scientists is crucial: for the protection, the restoration and the exploitation of Cultural Heritage, either by transferring to this field technologies developed in different areas, or by developing new scientific tools suitable for specific domains in Cultural Heritage.

Science is universal by definition. However, the presence in the Mediterranean Basin of so many art objects and buildings and the activity of so many experts in this area should convince scientists of all over the world to experiment here their skills.

We do really need very skilful scientists: the cost to develop new products for the preservation and conservation of cultural heritage is enormous and any future involvement of enterprises, particularly SME’s, depends on the answers coming from scientists.

However, up to now, any scientific approach has been random, ephemeral, often consequent to natural catastrophes like earthquakes which are so frequent throughout the Mediterranean Basin, or consequent to disasters provoked by men.

For this reason we suggest that European Union should exploit any possible formula to increase exchanges of visiting scientists between Europe and countries of North Africa and Middle East.

But we need not only scientists, we need also innovative enterprises.

Innovation is a fact of life: it is true for individuals as well as for enterprises. Once electric power was available, most candle manufactures simply got bankrupt or changed their business.

However, enterprises face many problems we should carefully understand if we want their support:

1 - the market is too narrow, often restricted to services and treatments for a single town;

2 - the main contractors are generally Public Administrations. This fact means enormous delays in payments;

3 - small enterprises access with difficulty to bank credit anytime they want to innovate their technologies;

4 - many small and micro enterprises simply ignore national and international opportunities to self- financing research projects.

In any case, if we want to help existing enterprises or promote new ones in the area of cultural heritage we urgently need at least to know who and where they are all over Europe or the Mediterranean Basin.

It may sound bizarre, but, as far as I know, even in Europe, it does not exist any adjoined database of these enterprises, giving details about their field of activity. How can we contact them if simply we ignore their address and what they do?

#### **5 – Our contribution: EACH Project**

As a matter of fact, no well organised, scientifically conceived project has been prepared and put in action under strict scientific control and with the direct involvement of Public Administrations all over the Mediterranean Basin. A preliminary successful attempt was carried out in Italy between 1997 and 2005 with a Special Project on “Cultural Heritage” by the National Research Council of Italy (CNR) which invested in coordinated researches of Italian scientists more than 30 million euro.

The Project we are presenting today as a preliminary draft deals with the safeguard of Cultural Heritage in countries of the Mediterranean Basin. The meaning of this acronym is ***“Euro Mediterranean Agency for Cultural Heritage”***

where the English word “each” simply means that each one, each citizen in our countries is responsible for the preservation of our cultural patrimony.

The final approved Project will be then submitted to national Authorities and to the European Union in order to be included among the Actions of the next European Commission Framework Program of 2015.

The specific philosophy of the Project is:

- 1 - Preparation of an Euro Mediterranean Project that will respect the Cultural Identities of all the Partners.**
- 2 - No single Research Groups but only Common Target Groups should be financed; these Target Groups should have National Public Authorities approval. National Public Authorities should take the responsibility of using the "products" realized by the Target Groups.**

This second point is of crucial importance! Just to avoid the usual procedure that unfortunately has been the weak side of many Call for Proposals of the European Commission Framework Programs: very many projects financed according to their “excellence”, carried out by small research groups with no common points, and with scarce or no impact on public utility. How many local Authorities in our countries during the last twenty years really used or exploited the “results” of these researches, which nonetheless had a cost of many million euro coming from the taxes paid by all of us?

In other words, the money spent was certainly useful for the advancement of science and technology but had a scarce impact on the safeguard of Cultural Heritage which basically remains on the shoulders of the Public Administrations, with scarce or no use of the scientific methods developed and reported on hundreds of scientific journals.

The Project to be discussed and approved during this Congress should give the maximum possible visibility to the Euro-Mediterranean Partnership: Cairo is one of the major Centres of the Mediterranean civilization and contains some of the major Cultural Heritage of the world, not only of the past but also of the Islamic art and it seems the right place to put together experiences and results coming from different countries of Europe, Africa and Middle East.

The Project will encourage the partnership among scientific organizations of Middle East, African and EU Member States..

It will support joint cultural initiatives and stimulate the innovation in this field for enterprises.

It will certainly strongly support networking among the various Target Groups and the local Public Authorities.

The major stakeholders that will benefit of this action are Public Authorities who have the duty to preserve their national and local Cultural Patrimony. But they have to change their attitude which is generally critical toward science and technology because, unfortunately, often scientists work ignoring the final user of their research; for this precise reason this action to be effective requires a strict and continuous interaction with Public Authorities.

It is worth observing that governments of the countries on the Mediterranean Basin spend every year for the safeguard of their tangible and intangible Cultural Patrimony billion euro and that a lack of common rules and guidelines imply that many million euro are wasted in incoherent or dangerous interventions!

This Project will lead to improved legislation, codes of conduct, at Euro-Mediterranean level, as far as preservation of Cultural heritage is concerned.

The final target of the Project is to enter as a specific action the next 2015 European Commission Framework Programme.

## **6 – Our tools: perseverance and optimism**

Ladies and Gentlemen, dear Colleagues, I’m sure you will give a significant contribution to save our cultural patrimony with your ideas, suggestions coming from your researches.

We will do our best to let them circulate among scientists all over the world, using all the opportunities modern information technology is offering to us.

But we need perseverance and optimism if we really want our ideas be accepted: in particular, if we want accepted our Project by European Union we need a lot of perseverance and patience, according to an old Arab saying:

الصبر مفتاح الفرج

“Patience is the key to the happiness”

Ladies and Gentlemen, dear Colleagues, we are entering the Congress with a preliminary draft called “EACH Project ” but my hope is that we may end up with a final document with a much more simple name “**The Cairo Plan for Cultural Heritage**”!

## **7 – Acknowledgments**

Let me express my deepest thanks to the members of the Organizing Committee of my team: A. Ferrari, M. Manfredi, E. Possagno, E. Sirugo, S. Tardiola

Thanks!

## حماية التراث الثقافى العالمى

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الساده

رئيس المؤتمر

الساده الحضور

اننى اشكر الساده منظمى هذا اللقاء الثقافى و اشكر لهم دعوتى لهذا اللقاء و اننى نظرا لأنشغالى حاليا فى الأمور التى تلت الأجتتماع الخاص بالدول الأعضاء بمنظمة ايكروم . اننى كنت اتمنى ان أكون حاضرا اليوم لأنه سرور كبير لنا ان نرى أن هناك لقاءات ثقافيه من أجل الحفاظ على التراث الثقافى فى كل بقاع العالم.

لقد عملت لأكثر من 40 عاما فى ميدان التراث الثقافى.

فمنذ عام 1966 بدأت العمل فى حقل تيبازا الأثرى بالجزائر. و الى الآن تقع على عاتقى مسئولية منظمة دوليه تعمل فى مجال الحفاظ على التراث الثقافى و حفظة و ترميمه.

اننى هنا اود ان اشير الى خطوات التطور العالمى للحفاظ على التراث الثقافى أولا : تطور مفهوم التراث الثقافى منذ الأجتتماع الأول للجمعية الدوليه للمهندسين المعماريين بمدينة اثينا عام 1931.

ثانيا : تطور أطر العمل القانونيه على المستوى الدولى مما أعطى دورا كبيرا للمجتمع الدولى بشأن حماية التراث الثقافى و ادارته.

ثالثا : اننى أذكركم ايضا بالمجال الثالث وهو تطور الاخطار على التراث الثقافى ليس فقط التغير فى المناخ و الكوارث الطبيعيه ، و لكن ايضا الأخطار الناجمه عن العامل البشرى و النمو العمرانى غير المدروس و الحروب و النزاعات التى تؤثر بشده على التراث الأنسانى.

السيدات و الساده الحضور

اننى اود ان اتسائل معكم عن ما هو معنى التراث الثقافى اليوم؟

ان مصطلح "التراث الثقافى" انما هو يتغير بتغير الظروف والوقت ففى السنوات الأخيرة تغير مفهوم التراث الثقافى و تطور الى حد كبير.

فبعد ان كان يشير الى مجموعات الأعمال الفنية المتميزه و المعالم الثقافيه ، اتسعت الفكرة لتضم التراث الصناعى و المعمارى الحديث و والتراث التحتمائى.

فالتراث الثقافى اليوم يشمل اشياء جديده و يطرح معان جديده لأنها تعكس التراث الحى وليس فقط صورا من الماضى. ففى خلال الأربعين سنة الماضيه اصبحنا نعى انه لا يمكننا ان نفصل بين الطبيعه و الثقافه حينما نتكلم عن التراث و اردنا ان نعطى صورة حقيقيه لتنوع المظاهر و التعابير الثقافيه.



ان اتفاقية اليونسكو عام 1972 من الوثائق الدولية الأساسية المتعلقة بحماية التراث العالمى و التراث الطبيعى و التى تم التصديق عليها من 184 دولة حتى يومنا هذا. وهى من أكثر الوثائق انتشارا وشعبية و فى الواقع نحن نقرب فعليا من عالمية قبولها.

ونقتبس من البند (1) من اتفاقية 1972 ما يلى: "تحقيقا لأهداف هذه الاتفاقية فان الآتى ذكره سوف يعتبر "تراثا ثقافيا": المعالم ، و مجموعة المباني ، و المواقع".

ولقد تم مؤخرا تركيز الاهتمام على وضع المفاهيم وتعيين البعد التكميلى للتراث، وهو البعد المتصل بالفكرة الجديدة للتراث الثقافى غير المادى. وقد جاء هذا نتيجة تركيزا أكبر على الفرد ، أو انظمه المجتمع الروحية والفلسفيه.

وهكذا اصبح التراث الثقافى حقيقة معقدة و بات عرضه للتهديد بعد ان صرنا نحن أشد وعيا بالدور الذى يلعبه فى حياة مجتمعاتنا و نموها و تطورها. ولقد بدأ الوعى بأهمية التراث الثقافى و صيانتة و الحفاظ عليه مع اعلان ميثاق اثينا 1931 و لاحقا مع ميثاق البندقيه لعام 1964 الذى اعلنه المجلس الدولى للمعالم و المواقع "ايكوموس".

و منذ صدور توصية نيروبي عام 1976 المتعلقة بالحفاظ على المدن التاريخيه / عملت منظمة اليونسكو على وضع مقاربة استراتيجيه تعتبر "التراث الحضارى" هو نقطة البدايه فى كافة السياسات الحضاريه.

كما تم لاحقا تضمين العناصر الرئيسيه لتوصية منظمة اليونسكو فى نيروبي فى ميثاق المجلس الدولى للمعالم و المواقع "ايكوموس" الذى صدر فى توليدو – واشنطن عام 1987 لحفظ المدن التاريخيه و المناطق الحضريه و صيانتها.

سيدى الرئيس ، السيدات ، الساده

ان المقاربه الجديده للتراث الثقافى و الاتفاق العالمى حول رؤية قائمة على الابتكار و التطوير للثقافه المنسجمه و المجدده و المبسطه من خلال تجربه اللجنه الدوليه للثقافه و التنميه، و مؤتمر ستوكهولم لعام 1998 هى حاليا قيد التفعيل فى العديد من الحالات كما ينبغى ادماجها ضمن كافة برامج المنظمات الدوليه الحكوميه و غير الحكوميه مثل منظمة اليونسكو و منظمة الأيكروم و المجلس الدولى للمعالم و المواقع "ايكوموس".

ومن المهم ان نذكر بأن القانون التأسيسى لمنظمة اليونسكو أوكل اليها "أن تنظر فى حفظ و حماية التراث العالمى بما فيه من الأعمال الفنيه و المعالم ذات الأهميه التاريخيه أو ذات الأهتمام العلمى".

وطوال ما يربو على الخمسين عاما ، نشطت منظمة اليونسكو فى تعزيز و تنظيم العمل الدولى فى هذا المجال الذى يعتبر مفتاح هويتنا ومصدر وحيانا.

و بهذه الروح اعتبر مؤسسوا منظمة الأمم المتحده للتربيه و العلم و الثقافه " اليونسكو" البحث العلمى وبناء القدرات من الأهتمامات الكبرى فى ميدان التراث الثقافى، فأسسوا منظمة ايكروم (وهى المركز الدولى لدراسة و صيانة و ترميم الممتلكات الثقافيه) كهيئه حكوميه وذلك فى عام 1956 ، أى منذ خمسين عاما وأكثر.

و على مدى هذه السنوات الخمسون استمر مفهوم التراث الثقافى فى الاتساع و اتسعت المسأله بسرعه لتغطى مجموعات المباني، و المعمار المحلى و التراث الصناعى و تراث القرن العشرين المعمارى وكذلك الحقائق التاريخيه من مفهوم "المشهد الثقافى"، و اليوم تؤدى بنا المقاربه الأنثروبولوجيه الى اعتبار الحقائق التاريخيه مجموعة اجتماعيه من عديد من

**مظاهرها المترابطة المختلفة و المعقدة.** و يعكس التراث الثقافى الآن فى معناه الواسع تنوع تلك المظاهر الثقافيه.

وقد انتجت هذه الأفكار مقاربة اكثر شموليه خلال العقد المنصرم أفضت الى تقدير افضل للتراث غير المادى كمصدر من مصادر التنوع الثقافى و الخلق و الابداع و التنوع ويتضمن التراث غير المادى العادات والتقاليد الشفهيه ، والموسيقى واللغات ، والشعر، والرقص، والأحتفالات الدينيه، فضلا عن نظم الأستشفاء الشعبيه، ونظم المعرفة التقليديه و المهارات المتصله بالنواحى الماديه للثقافه.

وعلى مدى خمس عقود ، ركزت الأنشطة المعياريه و أنشطة وضع المقاييس فى منظمة اليونسكو على حماية التراث المادى عن طريق وضع عدد من النصوص وهى:

- عام 1954، اتفاقية حماية التراث الثقافى فى حالات النزاع المسلح؛
- عام 1970، اتفاقية وسائل تحريم ومنع التصدير والأستيراد و النقل غير المشروع للممتلكات الثقافيه؛
- عام 1972 ، اتفاقية بشأن حماية التراث الثقافى والطبيعى العالمى؛
- عام 2001، اتفاقية حماية التراث الثقافى التحتمائى؛
- عام 2003، اتفاقية حماية التراث الغير مادى؛

كما تم فضلا عما ذكر آنفا وضع عشر توصيات بشأن صون التراث الثقافى. وكان العمل المعيارى على المستوى الدولى عبارة عن تفكير حول كيفية تطوير الدول و تقديمها فيما يتعلق بتنمية ادارة المؤسسات المختلفه التى تتعامل مع التراث الثقافى وتعزيزه، سواء أكان منقولاً أم غير منقول.

أما فيما يخص المتاحف و حماية الممتلكات المنقوله، فان الحكومات فى كل مكان بدأت تظهر تفهما كاملاً ونحن نقوم فى عديد من الدول بالمساعدته على نهضة مزدهرة فى بناء المتاحف وجذب الزائرين لها.

ومع مرور الزمن، لم تعد النظرة الى المتاحف على انها "حصون" بعيدة عن العامه او انها مراكز تخزين لأشياء "غريبه"... بل أضحت جزءاً من اهتمام الجمهور.

وعلى مدى السنين فان التراث الحضرى الذى طالما كان يعتبر فى دول مختلفه بمثابة عبء عليها، بدأ ينال اهتمام القطاع الخاص وشهد عقد الثمانينات ازدهارا لعدد كبير من المبادرات الخاصه. وبالتوازي مع هذا التطور فان المشروع الذى بعثته منظمة اليونسكو و المسمى "الحملة الدولية لحماية التراث الثقافى" اعطى الفرصه لتنفيذ فكرة " التراث العالمى المشترك" واقترح نظاما للإدارة تكون بموجبه المجموعه الدوليه مهتمة و مشاركته و اتسعت النظرة الى المواقع الثقافيه بعد ان كانت المواقع الدينيه فقط اصبحت كل ما هو قديم معماريا فهى شاهد على الحياة الأقتصادية ، وهى كلها جديرة بالحمايه بوصفها ميراثا للأجيال القادمه.

**سيداتى وساداتى**

ان الأنتشار العمرانى غير المنظم والهجرة الكثيفه من الريف للمدن و التتيمه السياحيه المفرطه أفرزت كوارث بيئيه وجماليه وثقافيه فى قلب المدن التاريخيه. ايضا الحاجه للموائمه بين

الحاجة الاقتصادية و الاجتماعية للسكان و انسجامها مع النموذج الحضارى الأسمى دون المساومة على الهوية والأصاله أصبحت حاليا هى التحدى الأكبر. ان الدور الخاص بالثقافه هو العمل على وضع استراتيجيات تحمى المراكز التاريخيه وتعزز مناسبات الألتقاء والتبادل بحيث تترسخ الهوية الثقافيه فى تاريخها وتعددتها وتنوعها. ان ذلك يتيح تنمية التراث التاريخى للمدن وتطويره كى يعتبر ناقلا للتنميه المستدامه.

سيداتى وسادتى

ان كانت الحرب هى العدو الأول للإنسان فهى عدو ايضا لأفضل مافعله الا وهو الفن، والثقافه، والمعالم و التراث الثقافى والتاريخى بأسره. فكثير من العمال الفنيه دمرت على نر القرون، أعمال لم يتسنى لنا ان نتعرف عليها ولن نراها ابدا مرة ثانية.

وعلى نحو متزايد ، تستهدف النزاعات الرموز الثقافيه حتى تدمر هوية الشعوب. وبعد ما حدث اثناء الحرب العالميه الثانيه صدرت اتفاقية لاهى لعام 1954. و المجموعه الدوليه مدعوة اليوم وطوال عدة سنوات الى تقوية الدور الذى تلعبه فى تنسيق عمليه معقده لترميم التراث المدمر خلال النزاعات المسلحه. ويكون التراث فى كثير من الأحيان هو المستهدف بالتدمير لما له من قيمه كرمز وكهويه.

وقد عهد الى منظمة اليونسكو بهذا الدور وهى التى نفذت بالفعل سلسله من البرامج الخاصه استجابة للأحتياجات الدوليه المتزايدة وها هى بعجاله المعطيات:

**المحور الأول أفغانستان :** حيث كانت المبادره لألغاء مرسوم طالبان لتدمير نصب باميان البوذى. وعقدت لقاءات مع ممثلى الدول الإسلاميه ووجهت نداء الى سيادة الرئيس حسنى مبارك ومهمة عاليه المستوى الى قندهار تضم علماء المسلمين بدعم من سمو امير قطر و توجيه نداء الى حكومة باكستان. وكل هذا ذهب هباء بسبب تعنت نظام طالبان .

وفى يونيه 2001 و اكتوبر 2001 وافق المجلس التنفيذى و المؤتمر العام لمنظمة اليونسكو على القيام بنشاطات طارئه وعاجله ، أهمها خاصة انشاء لجنة تنسيق دوليه للحفاظ على التراث الثقافى الأفغانى. وتبع ذلك عقد مؤتمر لليونسكو بالدوحه فى ديسمبر عام 2001 بالتنسيق و التعاون مع كل من منظمة المؤتمر الإسلامى، والمنظمه الإسلاميه للتربيه والثقافه والعلوم "الكسو"، وبحضور مديريها العاملين الثلاثه، وقد رأس الاجتماع سمو الشيخ حمد بن خليفة امير دولة قطر العربيه، وعمل منظمة اليونسكو مستمرا من خمس سنوات.

**المحور الأول العراق:** عندما تلقت منظمة اليونسكو معلومات بحرب وشيكة على العراق ، بادرت انا شخصا بصفتى مديرا عاما مساعدا للثقافه فى المنظمه بالعمل على ارسال رساله الى الممثل الدائم للولايات المتحده و الى سفير المملكه المتحده لدى اليونسكو نذكرهما بأحكام اتفاقية لاهى لعام 1954 و بأن العراق من الدول الغنيه بالتراث الثقافى بالشرق الأوسط و نوهنا الى اهمية ما يحويه متحف بغداد. كما ارسلت اليونسكو قائمه تضم من 20 الى 30 موقعا هامه بالعراق ن مثل بابل و نينوى وهاترا وأشور و أوروك و أور. ولم نتلقى للأسف أى اجابه قبل الهجوم المسلح.

وخلال شهرى يناير وفبراير 2003 كنت على اتصال دائم مع عدد من العلماء الأجانب العاملين فى العراق لتزويدهم باكثر ما يمكن من المعلومات ذات الصله بالتراث الثقافى العراقى.وقد

شهدنا ونحن عاجزون خلال شهر ابريل عام 2003 ن على التلفزيون تدمير المؤسسات العراقية ونهبها وبشكل خاصة سرقات المجموعات الأثرية بمتحف العراق. وعبر العالم كله عن استياءه ولكن اللصوص استمروا بعيدا عن كاميرات التصوير فى نهب المواقع الأثرية لهذا القطر العربى.

ورغم الظروف الصعبة ارسلت اليونسكو بعثتين الى العراق فى منتصف مايو و بداية شهر يوليو وضمت البعثتان رؤساءبعثات أثرية من المانيا وايطاليا واليابان و الممكلة المتحدة الولايات المتحدة الأمريكية. و البعثتان اللتان ارسلتا معى شخصيا كانت مختصتان فى علوم المتاحف والمكتبات والرشيف و المحفوظات من كل من الدانمارك وفرنسا والعراق وهولنده فضلا عن ممثلى النتربول الدولى.

وقد عمل كل هؤلاء على وضع خطة طوارئء بهدف اعادة تأهيل المؤسسات الثقافيه العراقيه.

### **المحور الثالث : الأراضي الفلسطينية و القدس الشريف:**

ان المواقع التراثية التاريخيه فى فلسطين فى نابلس والخليل و اريحا تناولتهم منظمة اليونسكو بالدرس و الصيانه وعمليات الأبرار و الأحياء عام 1994 و 2005 ثم بالمراقبه و المتابعه و الرصد منذ تفاقم الوضع من جراء الأحتلال العسكرى حتى يومنا هذا.

ويجدر بنا الإشارة الى ان المحور الرئيسى هو صون مدينة القدس الشريف المهددة بالخطر رغم ادراجها ضمن قائمة التراث العالمى، وسهر منظمة اليونسكو على المحافظه على اهم مقومات تراثها الحضارى ومعالمها الدينيه ومواقعها التاريخيه وفى هذا الشأن تحولت الى المدينه المقدسه فى شهر مارس عام 2007 بطلب من السيد مدير عام اليونسكو وقد شاركت ضمن لجنه دوليه فى معاينه الأشغال التى قامت بها سلطات الأحتلال فى حى المغاربه و قدمنا اثرها تقريراً رفع الى المجلس التنفيذى باليونسكو طالبا ايقاف الأشغال الجاريه هناك وهو ما تم.

### **المحور الأخير : لبنان:**

اخيرا وليس آخر استسمحكم للتذكير بأن منظمة اليونسكو ، علاوة على اهتمامها الدؤوب بالتراث اللبنانى فى مدن " صور " و "صيدا" و "جبيل" و "طرابلس الشرق" وغيرها من المواقع الشهيرة ، قد بادرت اثر الجتياح الاسرائيلى للأراضى اللبنانيه فى شهر يولييه 2006 بارسال لجنه مراقبه دوليه قامت بمعاينه وضع المعالم التاريخيه و المواقع الأثرية والممتلكات الثقافيه بما فى ذلك المتاحف. ولقد شاركت فى هذه اللجنه كرئيس لها وقدمنا تقريراً بذلك الى المجلس التنفيذى لمنظمة اليونسكو فى جلسة ابريل عام 2007.

### **الخاتمه**

من "سراييفو" عبر "باميان" الى "انكور" ثم "القدس الشريف". كان التراث الثقافى فى السنوات الماضيه فى الغالب هدفا حربيا او نقطة للنزاعات السياسيه أو العرقيه أو الدينيه. ولكن عندما عاد السلام فى الربوع تمكنا من اعادة تأهيل هذه المواقع ذات القيمه الرمزيه العاليه فضلا عن اللقاءات الثقافيه أو أشكال التعبير الثقافى التى تعتبر من التراث الثقافى غير المادى ، وقد ساعدت أحيانا على تعزيز عملية المصالحه الوطنيه وتقويتها و احياء النشاط الأقتصادى.

ويسرنى ان اختم بكلمات السيد مدير عام منظمة اليونسكو التى تلخص ما سبق و قلناه: "ان التراث الثقافى لشعب ما هو الا ذكرى ثقافته الحيه. ويتم التعبير عنه فى عدد من الأشكال الماديه وغير الماديه. ان أصول هذا التراث متنوعه ايضا؛ فهى تكمن فى اعادة تتبع نسبها الثقافى الخاص بها، وفى الاعتراف بالتأثيرات المختلفه التى ميزت تاريخها وشكلت هويتها،

فبإمكان الشعوب ان تبنى علاقاتها السلميه مع الشعوب الأخرى بطريقة أفضل، وأن تعمل على متابعة ما يكون فى الغالب حوارا قديم العهد وأن تصوغ مستقبلها وتشكله".

واخيرا أود أن انوه لسيادتكم عن أهمية التدريب الذى نعتبره عنصرا أساسيا من عناصر السياسات المدرجه لحماية التراث الثقافى، وفى هذا المجال أريد فى نهاية هذه الكلمة ان ابرز دور منظمه ايكروم الدولى فى برنامج طويل الأمد أطلقتها المنظمه فى عام 2004 و بدأ تنفيذه أولا فى كل من الأردن وسوريا و لبنان و الشارقة وهو برنامج "آثار". ويركز هذا البرنامج على مواقع التراث العالمى فى الوطن العربى وهدفه الأجمالى هو حماية التراث الثقافى الغنى فى الوطن العربى وتعزيزه وتقدير ماضيه وفهمه حتى اليوم، وما زالت الإدارة العامه لتنمية التعاون فى وزارة الخارجيه الإيطاليه (DGCS) هى الهيئه المموله الأولى للبرنامج و منذ عام 2006 و بالتعاون مع منظمة الأليكسو توسع هذا البرنامج ليشمل جميع الدول العربيه.

ان من خلال الصور التى ساقدمها سيتضح دور هذه الدورات التدريبيه التى قامت بها منظمة ايكروم من خلال برنامج آثار منذ عام 2005 الى يومنا هذا فى سوريا ولبنان و الأردن ومؤخرا فى اسطنبول فى دورة تدريبيه فى مشاريع الترميم المعمارى فى العراق خصصت لخبراء من المهندسين و المعماريين بالعراق لكى يتولوا دورهم فى الأشهر القليله القادمه فى ترميم مسجد الأمام العسكرى بمدينة سامراء.

اسمحوا لى ان أغتنم هذه الفرصه الثمينه لأطلب من سيادتكم المساعده فى توسيع برنامج "آثار" فى المنطقه العربيه ودعمه بموارد ماليه حيث أن أكبر الدول من أعضاء ايكروم المموله لاتريد فى الوقت الحالى أى زياده فى الميزانيه،

انى اذ اشكركم مسبقا لتلبية هذا الطلب.

وفى الحفظ دمتم جميعا ن والسلام عليكم ورحمة الله،،

منير بشناقى

المدير العام

المركز الدولى لدراسة وصيانة وترميم الممتلكات الثقافيه \_ " ICCROM "

6 ديسمبر 2009

# ITALIAN-EGYPTIAN CENTRE FOR RESTORATION AND ARCHAEOLOGY

GIUSEPPE FANFONI

*CIERA Shari Es Siyuftiyah, 31 Helmiah -11411- Cairo-Egypt*

## 1 THE MONUMENTAL AREA

The Italian-Egyptian Centre for Restoration and Archaeology (CIERA) operates in one of the largest monumental areas of the historical Cairo, covering over about 7.500 square meters near the Mosque of Sultan Hassan, close to Cairo Citadel, in the Hilmiyah district. Its complex of buildings offers an extraordinary range of different periods and styles including architectural, historical, artistic monuments and archaeological remains relating to a period ranging from the 7<sup>th</sup> to 19<sup>th</sup> centuries.

In particular, the most remarkable buildings (fig. 1) are:

- The Palace of Qusun-Yashbak-Aqbardi: built by subsequent additions between the 14<sup>th</sup> and the 16<sup>th</sup> centuries, this is the largest part of the monumental area.
- The Madrasa of Sunqur Sa'di built in the 14<sup>th</sup> century and the underlying archaeological area with remains of settlements of different periods starting from the 7<sup>th</sup> century A.D.
- The Mausoleum of Hasan Sadaqa (14<sup>th</sup> century), with its minaret characterized by an exceptional "hilal" (consisting in a dervish hat, instead of the most usual Crescent).
- The Sama'khana: a "Theater" built by Mevlevi Dervishes (18<sup>th</sup> - 19<sup>th</sup> centuries) for the performance of their circular dance, typical of their mystical confraternity. Its construction was inspired by deep symbolic meanings, and it is one of the last existing examples of this rare architectural typology.
- The "Takiyya", that is the "Convent" of Mevlevi Dervishes. Its building started in 16<sup>th</sup> century, in the area between the remains of the Madrasa of Sunqur Sa'di and of the Yashbak Palace, and by reusing, as far as possible for the new function, the ruins of the old monuments.

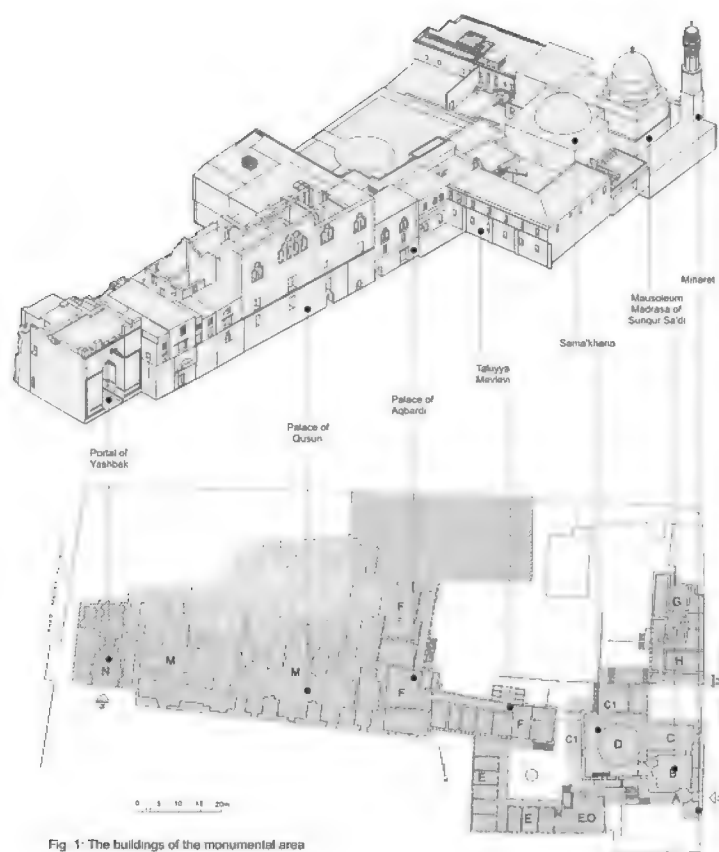


Fig. 1- The buildings of the monumental area



## 2 THE ORIGIN OF CIERA

I started my restoration activity on these buildings by coming in Cairo few months per year, for some lessons on restoration in Gizah University, where a new Restoration Department had been opened since 1976. My name had been proposed by the regretted Prof. Carla Burri, at that time Director of the Italian Institute of Culture. During a conversation concerning my wish to teach by practical training on the monuments, she proposed me, in this aim, the recovery of "a little theatre", the Sama'khana.

From my preliminary visit and few researches on the place, the Sama'khana resulted just a small part in a very wide architectural area and that it was strictly linked, both historically and structurally, to other huge and ancient monuments.

The area was completely in decay, but the importance of its monuments required its recovery in the whole. As to the Sama'khana itself, no doubt that it was the building in the most imminent danger, since it presented heavy structural damages and the dome was going to collapse. The restoration started by supporting the Sama'khana with wood scaffoldings and by beginning the survey and the study of monuments.

## 3 THE WORK SITE SCHOOL

Shortly, after starting my restoration works, I could also move my teaching site from Gizah University to Shari Es Siyufiyyah: and, since its beginning, the new didactic centre had the character of teaching and learning by a contemporary work and study, which has been kept till now, as "*cantiere-scuola*" work-site-school.

Many years have passed from that time and many monuments have been recovered in this area (fig. 2) by teachers, students and artisans together in our Centre.

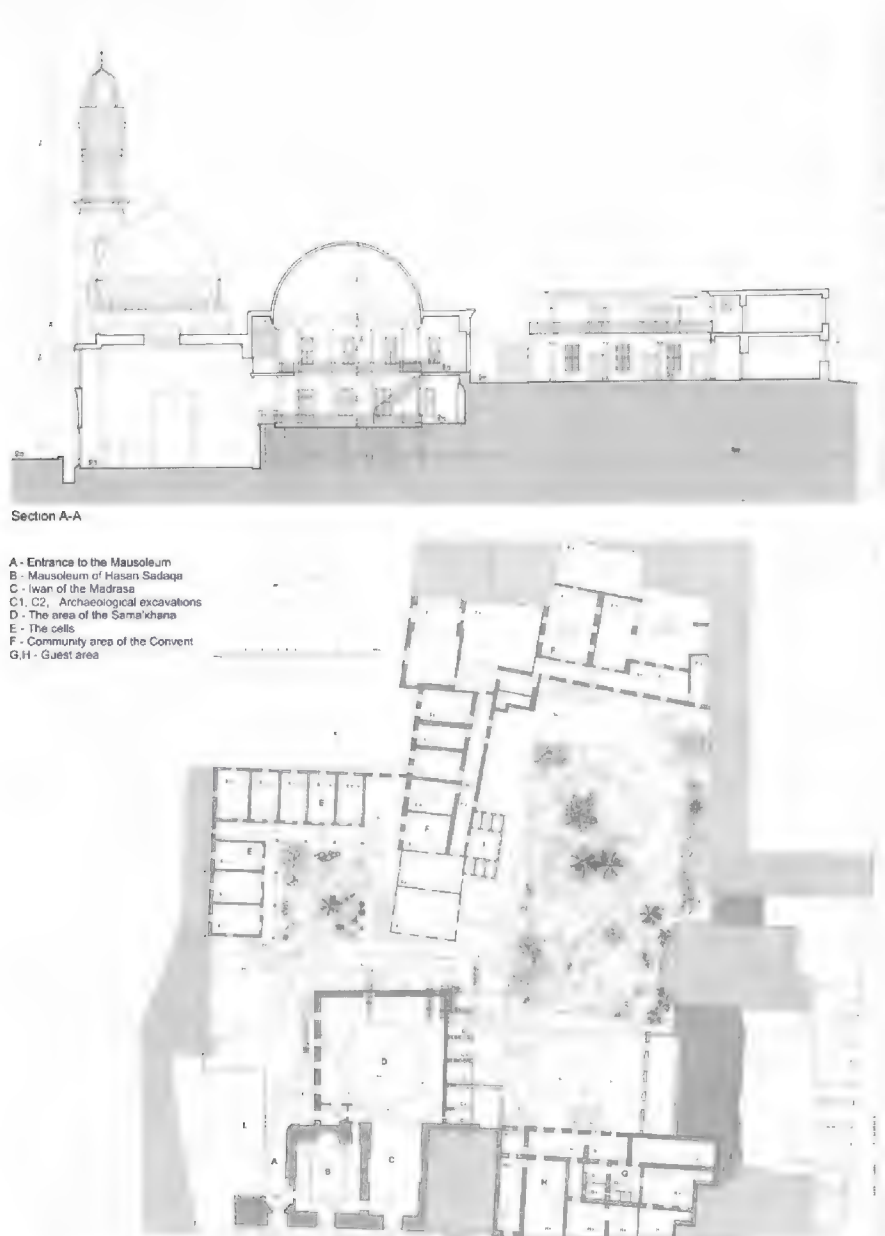


Fig. 2: General plan and section of the Mevlevi area

#### 4 GUIDE PRINCIPLES OF THE RESTORATION INTERVENTIONS

All the courses were carried on by working in our laboratories and with the practical restoration interventions although teaching and working contemporarily require time and continuous control.

Special attention was paid to all interventions (fig. 3) in accordance with the following concepts:

- *Visibility* of the interventions
- *Compatibility* of the materials used with the original ones
- *Reversibility* of both materials and intervention, where possible.

Special attention was paid also to the preservation of the original shape (fig. 4) and the technique of the monument, by using:

- *Minimal intervention* to preserve the shape
- *Supporting structures*, in case of structural interventions, to preserve original techniques and technologies
- *Detailed documentation*, before, during and after the interventions, especially in case of changes. Where possible, documentation was produced "in situ".

The system of teaching and learning chiefly by practical activity and the variety of specializations have required more and more the presence of numerous technical teachers: it has been possible because the Centre is managed from many years by the no-profit association CFPR, whose the teaching staff is taking part.

Most of the Italian teachers are from State Institutes of Art; other ones from various Restoration Institutes, from the National Council for Research and also from Rome University "La Sapienza", Naples University "L'Orientale" and Venice University (IUAV). Besides, Egyptian professors have participated to the experience our didactic activity.

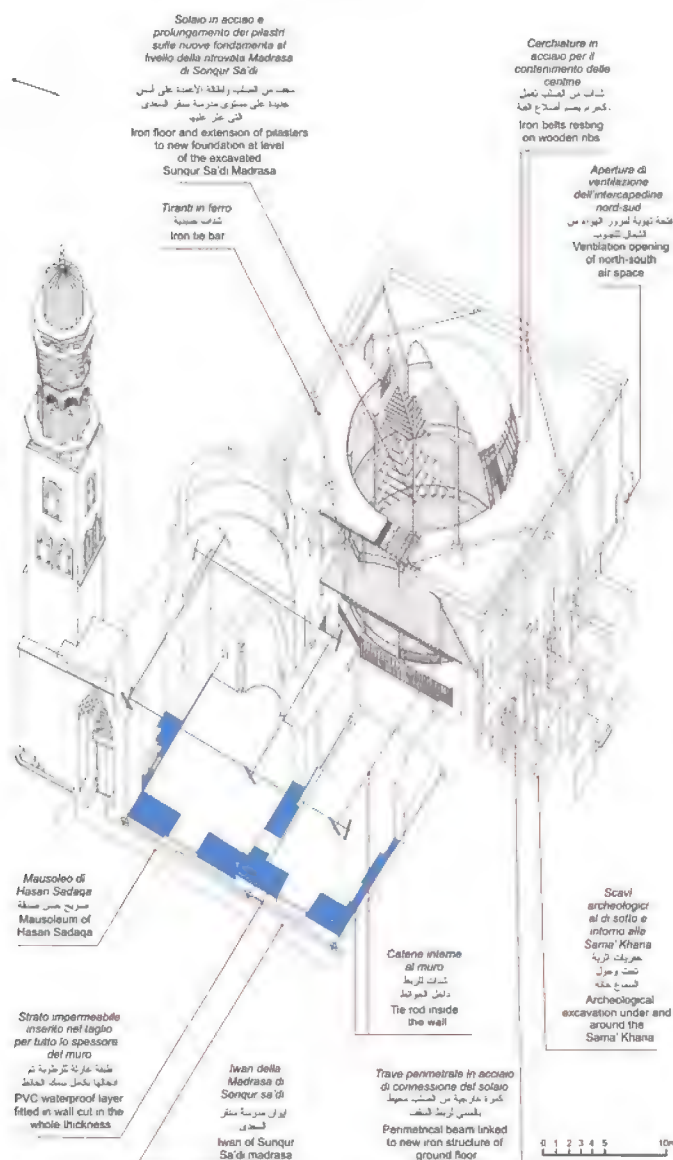


Fig. 3: Technical interventions carried out in the Mausoleum, in the Madrasa and in the Sama'khana



Fig. 4. Differentiated and distinguishable integrations of the restored stuccoes

## 5 THE RECOVERED MONUMENTS

In 1988 the Sama'khana, currently considered the most significant building in the world of this architectural typology, was opened to the public. On that occasion, the Italian Ambassador Giovanni Migliuolo and the Egyptian Minister of Culture Faruk Hosni formalized the Italian organization of the "*cantiere-scuola*" officially, by inaugurating the C.I.E.R.A.

In 2002 the Madrasa of Sunqur Sa'di, whose recovery had required long and complex excavations under the Sama'khana, was opened to public. The excavations have brought to light important historical ancient remains.

From 2002 we have finished the following buildings:

- 1<sup>st</sup>) The Mausoleum of Sunqur Sa'di (commonly known as "of Hasan Sadaqa"), where the excavation works have discovered the marble cenotaph, now visible under the centre of the dome;
- 2<sup>nd</sup>) The block of cells of the Mevlevi Convent, around the little garden and facing the Sama'khana;
- 3<sup>rd</sup>) The block of flats facing Shari Es Suyufiya and flanking the Convent entrance. The location of the building was particularly suitable to its reuse, in the respect of the old structure, as an area for exhibitions and congresses. It is here that we have presented our exhibition, now itinerant in Italy and Egypt in the frame of the "2009 Italian-Egyptian year of science and technology": its subject, "Restoration and Restorers" is concerning the activities in the Centre carried out in the years 2002-2007.

## 6 THE SPREADING OF THE RESEARCH AND DIDACTIC RESULTS

The methodology and technology with the description of the restorative interventions and the didactic results in these years are also the subject of my book "The recovery of the Sunqur Sa'di Mausoleum and the restoration of the Takiyya Mevlevi".

Both the exhibition "Restoration and Restorers" and the book aim to give information about the activity of our Centre which we consider of primary importance for the recovery and conservation of monuments: that is the training of personnel specialized in the restoration field at various levels (support artisans, specialized professional operators, coordinating professional operators) and in different activities (architecture, archaeology, fine arts), according with the basic culture and qualifications of the persons.

People attending our courses have been more and more various and numerous in time, and: during the training program 2002-2007, they were more than 500 including:

- a) 3 professional coordinators, 39 restorers and 87 artisans from the SCA staff, who attended the whole courses;
- b) 88 university students and 71 private artisans, for attending short training programs;

c) 241 professional operators in the restoration field, requiring up-to-date informing lessons. At the end of his activity, each participant had a certificate attesting the acquisition of his professional qualification.

## 7 THE OBJECTIVES IN THE CONTINUITY

The work site school is like a large laboratory (fig. 5) where the scientific and technical information is transmitted by the daily work; it is not a place for the academic teaching, but it offers a practical experience supporting also academic courses: many graduation theses have been carried out here in collaboration with Egyptian Universities.

The didactic system of the Italian Egyptian Centre has formed many specialists who are now operating, in Academic or Scientific Institutions. In other cases, the professional specialization we give offers a great opportunity for entering the labour-market. A lot of artisans, technicians and simple workmen improved, in the work site school, their knowledge and artisan ability, and now they spread everywhere this know how by means of their daily activity. They are the tool and the indispensable base of every organization and social development, particularly in the restoration and conservation sector.

Such a wide didactic activity confirms the aim of the Centre to promote the culture of heritage and the of memory, both referring to the deep identity of the man.

The project "Development versus Conservation", recently proposed by Unesco Cairo office, as "Environmental Day" on 2<sup>nd</sup> December 2009 in Helmiya quarter with the collaboration of the CIERA, is strictly linked to the aim of the didactic activities of the Centre in order to instil in the consciousness of the children and young people the respect of the environment and of the historical monuments as culture their the memory; because for the human being, there is no future without the knowledge and consciousness of the past.

I would just conclude by expressing my gratitude to the Italian Ambassador Claudio Pacifico and to the Minister Faruk Hosny for the promotion of the Italian Egyptian Centre, particularly by the recent MoU between the Italian and Egyptian Governments, that gives new perspectives for the sustainability of the CIERA projects.

Finally I wish, the success of the "Cairo Plan for Cultural Heritage" in the future, as it is in the aim of this important event of the present Cairo-Congress 2009.

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# **THE ITALIAN GEOGRAPHICAL SOCIETY: PROTECTING OUR COMMON CULTURAL PATRIMONY**

**FRANCO SALVATORI**

*President of Italian Geographical Society*

Ladies and gentlemen,

as President of the Italian Geographical Society I want to express to the Organizer of this important Congress the interest of the Italian geographers for what you are doing to help safeguarding cultural heritage of the Mediterranean countries.

Since 1867 we have been working as a Society to increase the knowledge about national territory and other regions of the world and in particular the regions of the Mediterranean Sea. Our library contains approximately 400,000 books and over 2,000 periodicals and it is one of the largest in Europe. Analogously we possess a complete collection of modern maps and thousands of rare books and hundreds of maps and atlases ranging from '400 to '800 centuries.

Nowadays we organize many cultural events concerning the protection of cultural heritage all over the Mediterranean Basin with particular emphasis to landscape and territories, discovering and discussing the similarities among populations and historical cities of the countries facing the Mediterranean Sea.

The Italian Geographical Society is particularly interested to increase the knowledge concerning monuments of the Mediterranean area which is the cradle of western culture: monuments should be considered not only those of material evidence like statues, historical buildings, etc. but also any evidence of our civilisation i.e. popular traditions, costumes, anthropized landscape, etc.

The Society collaborates to many national and European projects concerning these topics and in particular in the sector of tourism, which is significant all over Europe and in particular in the Mediterranean Basin.

There were in 2008 approximately 900 million tourist arrivals all over the world and 50% of them concerned Europe. Egypt was the most visited country of the Middle East with about 12 million arrivals. These data give an idea of how impressive is this phenomenon and consequently how important is our mission to help this impressive "travelling population" of tourists to better know and be aware of our common cultural patrimony.

Among the initiatives of the present Congress, the Italian Geographical Society is particularly honoured to assign a special award in memory of prof. Alberto Vallega, one of the most important European geographers, to Fiorella Dallari professor of Economic Geography at the Bologna University who has been working for many years on cultural routes of Europe and Africa and spent many years in your country, Egypt

This Congress is also the right way to set up a relationship among European Countries and the Countries of North Africa and Middle East; our Western civilization flourished around the Mediterranean Basin. This area is the right place to experiment science and technology for the safeguard of Cultural Heritage of all over Europe. In fact, choosing the Mediterranean Basin means choosing an area rich of monument of any kind, and consequently, according to the criteria of the European Union Commission, here there is the so called "European Added Value" needed for the European Projects carried out inside the Framework Programmes. Endly, we are opening this Congress in Egypt which is one of the most active and successful country of Middle East, rich of ancient and modern monuments. These monuments testify how significant has been the cultural contribution of this country and the papers presented by the Egyptian scientists will give to us the knowledge of their state of the art in this field.

So, let me welcome you, my congratulations again to the Organizers for their effort and I will read as soon as possible the results of your researches in the Proceedings of the Congress.

Thanks.



# CULTURAL HERITAGE AND SCIENTIFIC RESEARCH. THE ROLE OF THE DEPARTMENT OF CULTURAL HERITAGE OF THE CNR.

MARIA MAUTONE

*Director Dep. Cultural Heritage, National Research Council, Italy*

## **Introduction. The Department of Cultural Heritage**

The Cultural Heritage Department created in 2006 as a consequence of a general re-organisation of the Cnr is the scientific coordination body to which the National Research Council (CNR) has assigned the statutory task of linking up the activities of the research groups, each of which operating according to its specific competence, in the field of cultural heritage. The interdisciplinary nature of the cultural heritage sector, as reflected in the transversal nature of humanistic research and technological innovation, finds its adequate connecting node in the Department PC. In accordance with the agency's strategies, the latter promotes an 'integrated management' of the research in order to ensure greater territorial, economic and productive incisiveness for the policies related to the promotion and management of the heritage. It has the task to define the policy and to co-ordinate research activities of its Institutes. In accordance with the Cnr strategies, the Cultural Heritage Department promotes an "integrated management/governance" of research on cultural heritage with the aim of increasing the value of the heritage of a territory and of improving its management. The objective pursued is to provide Italy with a wholly innovative scientific network model, the main strength of which lies in the synergism between knowledge of a philological-literary, historical-archaeological, scientific-technological and economic-managerial nature capable of being linked up at international level. Strategy and strength of Cultural Heritage Department is an innovative model of scientific network able to establish fruitful co-operations and synergies between human and engineering sciences and operative expertise and skills, both necessary and inseparable knowledge in the field of research for cultural heritage. Another strength of the Cultural Heritage Department is the creation and the development of relationships with other public and private, national and international, players of the sector. These are private and public research organisations, Universities, networks of excellence, public bodies and companies. This network also involves international organisations, with whom the Cultural Heritage Department co-operates for all the matters concerning the participation to European research projects, the promotion of research results and the technology transfer activities

## **Institutes and Research groups**

Distinctive feature of the Cultural Heritage Department is the *integration of different scientific knowledge* of the 5 institutes that it co-ordinates and of about 25 research groups, belonging to other Departments of the Cnr, that collaborate with the Department's Institutes. Their areas of research cover different aspects of the research activities on cultural heritage. The conservation and the preservation of monuments and artworks is an *interdisciplinary* field requiring close co-operation between human sciences (philology, history, archeology, etc.) and natural sciences (chemistry, physics, geology, biology, information technologies, etc.).



Figure 1. *Non destructive* analysis on coloured pigments of an Ellenistic cinerary urn.



Figure 2. InfraRed spectrometer for measures in situ.

The Institutes of the Department themselves are specialized in human, historical and archeological studies/topics, on one



side, like the Institute for Aegean and Near Eastern studies (*ICEVO*), the Institute for the study on the Italic and Ancient Mediterranean Civilizations (*ISCIMA*) and the Institute of Archeological heritage monuments and sites (*IBAM*); and, on the other side, Institutes more devoted to the development and testing of technologies to be applied to cultural heritage, like the Institute for Technologies applied to cultural heritage (*ITABC*) and the Institute for the Conservation and enhancement of cultural heritage (*ICVBC*).

The main projects in which the research groups are

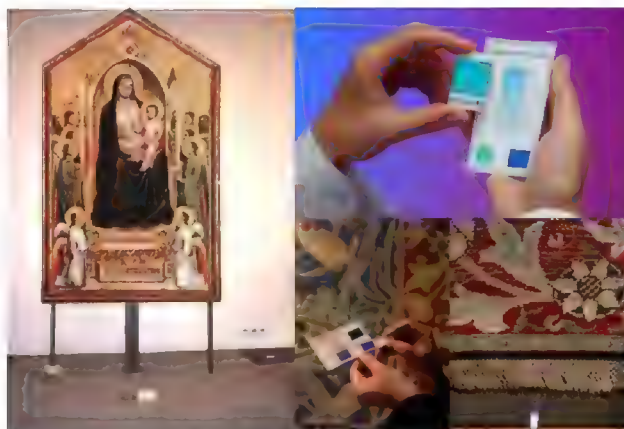


Figure 3. Light dosimeters to measure light levels inside exhibition rooms.



Figure 4. Virtual reconstruction of Duomo, Pisa.

involved, concerned the various aspects considered strategic by the Department. These are:

- 1) Historical knowledge of the cultural heritage
- 2) Archaeometric studies of artworks made of different materials
  - *Non destructive analysis on coloured pigments of an Ellenistic cinerary urn*
- 3) Development of methodologies and technologies for diagnosis and conservation
  - *Reflectography on LaVergine delle Rocce (Leonardo, 1483). The analysis permits an optimal reading of original images below the painting (National Institute of Applied Optics, INOA)*
  - *InfraRed spectrometer for measures in situ. Frescos of Agnolo Gaddi in Basilica di Santa Croce, Florence. XIV<sup>th</sup> c. (Institute of Applied Physics, IFAC)*
  - *Electrochemical Impedance Spectroscopy on the horse of the monument of Bartolomeo Colleoni of Verrocchio, Venice. XI<sup>th</sup> c. (Institute of Marine Science, ISMAR)*
  - *An acoustic map for the detection of the detachment of frescos. Frescos of Casa Vasari, Florence. XV<sup>th</sup> c. (Institute of Acoustics, IA)*
  - *Non-contact portable prototype for the detection of voids, cracks, detachments, holes in different kinds of materials (Institute of Atmospheric Sciences and Climate, ISAC)*
  - *Light dosimeters to measure light levels inside exhibition rooms (Institute of Atmospheric Sciences and Climate, ISAC)*
  - *Sensor for the detection of condensation on the surface of ancient stained glass windows. Sainte Chapelle, Paris (Institute of Atmospheric Sciences and Climate, ISAC)*
- 4) Research for the development of new materials and technical solutions for conservation
- 5) Development and improvement of ICT tools for increase knowledge, valorisation and use of the heritage
  - *Virtual reconstruction of Duomo, Pisa (Institute of Information Sciences and Technology, ISTI)*
- 6) Conservation project to orient technological choices towards integration of traditional and innovative techniques
  - *Reuse intervention in Bedestan, Nicosia ((Institute for Technologies Applied to Cultural Heritage, ITABC)*

For each one of these topics, research groups are able to reach results of excellence that are acknowledged and appreciated both at National and International level



Figure 5. Non-contact portable prototype for the detection of voids, cracks, detachments, holes in different kinds of materials.

### Approach to cultural heritage and strategy of research (the “chain”)



linked to the previous step and enhanced.

Relying on an integrated and multidisciplinary model of scientific network, the strategy carried out by the Cultural Heritage Department has its starting point in the approach of the heritage considered as a “chain”.

The different moments of a study or of an action on an artworks follow coherently one after the other with the aim of studying the various aspects of the heritage and so increase the its final value. The different moments of the “chain” include *knowledge, diagnosis, monitoring, valorisation, preservation, use and management.*

Such approach aims at joining various knowledge and expertise so that each moment of study or action can be

#### 3.1 Projects of the Cultural Heritage Departments, inter-departments projects, HERIT platform

The Cultural Heritage Department projects are organised according to the above mentioned “chain” approach and on a multidisciplinary network. This distinctive feature of the Department allows that knowledge and actions on the heritage can be realised with the best available sustainable and non-invasive technologies and with the best effective tools and methodologies that respect the quality and the integrity/wholeness of the artwork. Strategic board of the Cultural Heritage Department is the project “Cultural landscape”. The landscape is the record/file of signs that man left in a space over the time, signs that represents the identity of a community of a specific area/region. With its tangible (artworks) and intangible (culture) goods, with its natural human (built) elements, with its individual artefacts and its settlements, it (the landscape) is the single and only evidence that must be protected, organised and managed. It is the datum point of the value of a people of a nations and it can be, should be, the starting point for its economic development. Considered as a laboratory for knowledge surveys and a “study-site” for conservation actions, the “Cultural landscape” has a strategic relevance as it collects public and private players charged with managing, organizing, enhancing, and promoting it. According to this, the Cultural Heritage Department encourages projects or the society and for the economy in the general framework of the sustainable development.

The *Culture and Territory* project is developing in a wide project named HERIT (HERitage Research in ITaly), a kind of “cultural platform” that should collect and make operative/operating the available network of knowledge and expertise that exist in the cultural heritage sectors. Such initiative, coordinated by the Cultural Heritage Department, is shared within a wide network of public and private players such as the Ministry of Cultural Heritage, the Ministry for University and Research, the Ministry for the Economic Development, Universities, Museums, etc. Main objectives of the HERIT project are:

- ❖ *to create social value:* increasing the level of awareness, the participation of local public and private players, the development of training processes;

- ❖ *to create economic value*: promoting activities linked to survey, diagnosis, conservation, publishing, multimediality, show/performance, content provider, record industry, tourism, etc.

### 3.2 International cooperation

In such a strategic setup, the DPC aims to establish the technological framework in which the CNR operates at levels of excellence in a situation of international cooperation. These activities are implemented not only by means of processes of technology transfer among researchers and foreign users but also, thanks to the capacity to export its own know-how, through the coordination of, or participation in projects funded by institutions or by international funding programmes (Culture Programme, VII Research and Development Framework Programme, INTERREG Programme). Italy is recognized as having competence in the approach to restoration and our researchers not only export technology but also a global knowledge of the problem of conserving works of art in an overall vision in which all the relevant skills are combined. In the various international contexts, the DPC is thus a leading actor with significant experience in a field of great scientific interest that reflects actions identified as of priority and strategic importance.

If the archaeological researches performed on Crete are a response to the need for historical knowledge concerning the assets and their position in time and space, the 3D digital acquisition of the portal of the monastery of Ripoll in Spain represents a scientific sector in which the DPC is equally active. The European Euartech project is dedicated to the search for new materials for conservation, while the Bedestan restoration is one example of architectural restoration carried out using advanced technology. The new diagnostic techniques used to analyse bio-patinas, tested in the survey carried out on the Tacca fountain in Florence, have been widely disseminated and have for instance been applied to the study of the fountain in the garden of Lindaraja at Alhambra, Granada.

The international cooperation activities of the Cultural Heritage Departments are carried out **both** through the coordination and/or participation at international research projects (European Commission, Research and Development Framework Programme, CULTURE 2007 programme, INTERREG programme, etc) **and** through the technology transfer of know-how and patents. The Italian approach to conservation, acknowledged at international level, imply that our researchers are requested both for their technologies and their methodology. At the international level, the Department is therefore involved in many actions covering all the moments of the “chain”: from archaeological surveys to research and development projects, from training courses to technology transfer events. as you can see in these examples of international actions:

#### Archaeological studies

- SYBRITA settlement (CRETE)
- PRINIAS, early and middle Minoan settlement and cemetery (CRETE)
- CHAN CHAN, archeological complex (PERU’)

#### Research projects

- TEACH, technologies and tools to prioritize assessment and diagnosis for air pollution impact on immovable and movable cultural heritage (*EC 7FP*)
- MESSIB, multi source energy storage system integrated in buildings (*EC 7FP*)
- POPART, strategy for the preservation of plastics artifacts in museums collections (*EC 7FP*)
- 3D-COFORM, new tool for 3D digital artifacts (*EC 7FP*)
- SECHURBA, sustainable energy communities in historic urban areas (*IEE PROGRAMME*)
- Monitoring the micro climate in the cave of Lescaux (MINISTERE DE LA CULTURE, FRANCE)
- NOAH’S ARK, GLOBAL Climate Change Impact On Built Heritage And Cultural Landscape (*EC 6FP*)
- PREPRI Insediamento e necropoli dell’Antico e Medio Minoico a Priniàs, Creta (Grecia)
- PACE Plants and Culture
- PORTI E FARI Archeologia industriale marittima dell’Adriatico.
- COUPOLES et habitats seeds of the cultural heritage of Europe
- BYHERINET BYzantine HERitage NETwork
- RECES modiquess project La rete dei piccoli centri storici come modello di qualità urbana e sviluppo sostenibile
- PLACE Preserving places. Managing mass tourism, urban conservation and quality of life in historic centres
- PALAIS Patrimonio architettonico locale e gestione innovativa e strategica
- H-KNOW Advanced Infrastructure for Knowledge Based Services for Buildings Restoring
- BIOFILMS Biofilms on exposed monumental stones.
- SENSORGAN Sensor system for detection of harmful environments for pipe organs
- BEDESTAN Structural and architectonic restoration of the Bedestan, Nicosia, Cyprus
- EU-ARTECH JRA1 Development and evaluation of new treatments for the conservation conservation-restoration of outdoor stone and bronze monuments



- RIPOLL Virtual presentation of Ripoll portal
- V-CITY Virtual city

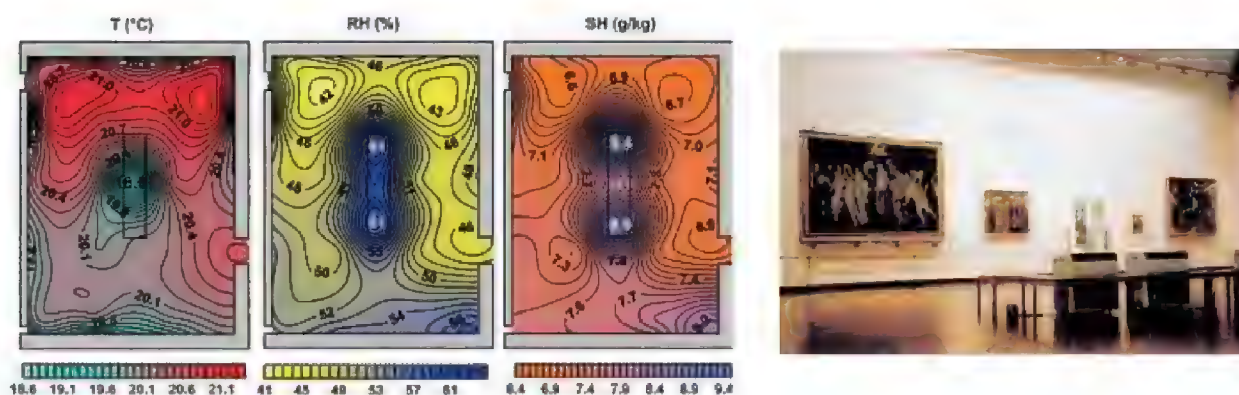


Figure 6. Horizontal sections of the Botticelli Room in the Uffizi Gallery, Florence (Italy), representing the isolines related to temperature, relative humidity and specific humidity.

#### Training action

- EPISCON, European PhD in science for conservation (*EC 6FP, MARIE CURIE ACTION*)

#### Technology transfer project and events

- CINEMA Central Italy Network to Enhance coMpetitive business Activities ENTERPRISE EUROPE NETWORK, an European network for Technology Transfer (*EC INNOVATION PROGRAMME*)
- TECHA2008 (1<sup>st</sup> edition in Rome), international forum and brokerage event on technologies exploitation for cultural heritage advancement (Rome, March 2008) – TECHA 2010 (2<sup>ND</sup> EDITION) (Arles, September 2010)
- DENKMAL, international fair and technology transfer day on built heritage (Lipsia, November 2008)
- BHeST2009, international exposition and meetings on Conservation; brokerage event on Built Heritage and Sustainable Technologies (Ferrara, March 2009)

#### Conclusions

The results obtained by these projects were inspired by integrated awareness and joint action regarding cultural heritage that unwinds around a chain of specialized knowledge and innovative technical methods. This reality is constructed of the new technologies and strong potential that the Department is developing through the coordination and support of researchers. The Department of Cultural Heritage develops its strategic guidelines through the consolidation of integrated projects, the reinforcement of interdepartmental collaboration in CNR and with universities and the enhancement of scientific reporting with the most important international institutions.





# SESSION A - ENCOUNTER OF CULTURES HISTORICAL CITIES

# **SESSION A1 - IDENTITY AND GLOBALIZATION**

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## **THE BEDOUIN POPULATION OF SINAI BETWEEN TRADITION AND GLOBALISATION**

### **BEDOUIN COMMUNITIES AND GLOBALISATION**

**RITA LOREDANA VINCI**

*University of Catania*

The historical conjuncture imposed by globalization has placed the Bedouin population, perhaps, for the first time after milleniums, face to face with such radical transformations from an economic, social and political aspect as to change its main characteristics.

Describing these transformations means, not only describing their impact on social and productive mechanisms consolidated over centuries of nomadism, but, also, whether it is possible to reconcile the Bedouins' traditions with the needs and the contaminations of an increasingly globalized economy.

The last representatives of a pastoral culture, the Bedouins have been able to achieve a delicate balance in a desert environment extremely poor in resources.

They inhabited the areas along the edge of pluvial and irrigated cultivations, and, from the seventh century A.D., when Islam was born, they began to develop politically and socially.

The Bedouin population, linked to the hyper-specialized economy of nomadic breeding, has never managed to free itself from the dependence on the agricultural and urban world, which attracts and repels alternatively. Hence the nomadic-sedentary dialectic that permeates the entire history of the Bedouins which, today, under the influence of globalization, tends to be weaker or schizophrenic in the secular contrast between breeding and agriculture.

Sedentary societies, despite the conflict that developed in the past for control of the territory, have always been in direct contact with the Bedouins, both economically and politically. For this reason it is not possible to consider the Bedouin society as a self-sufficient universe, separate from a broader context. The interdependence of the pastoral and agricultural communities, not excluding, as we have seen, the conflict between the two forms of appropriation of environmental resources, has contributed to characterizing the social history of all the Middle East.

The social organization of the Bedouin people is of a tribal and segmental type, but with the distinctive element, compared to other communities, of the particular nature of groups of extraction: social units bring together individuals on the basis of common descentence.

One must start from this concept, in order to understand the nomadic-sedentary dialectic in which nomadic breeding and sedentary agriculture are the extreme ideals of an integrated system of productive strategies.

With "modernization", the Bedouins have seen their areas of movement progressively reduced over recent years. The availability of imported new technologies profoundly alters these dialectics, taking away more and more space from the desert, and influencing both the social-economic order and the lifestyle of the Bedouins.

These changes are connected to the increasing role of the Middle East in the "global" game of world energy strategies. Foreign exchange from exports of crude oil have disrupted the economy and changed its profile. Within a few decades, the area of the Middle East has had to face the increasing demand of the market and a surge in prices.

The emission of this wealth on the economic circuit has developed an economy of large scale importation and favoured the emergence of new commercial élites.

From an economy widely based on subsistence and exchanges in kind, as agricultural and breeding was before the discovery of oil and the advent of globalization, in a few decades it has changed to an almost entirely monetarised market economy. In this context, the Bedouin societies whose productive activities were essentially directed to subsistence, have developed forms of economic adaptation that involve different ends.

The development of a monetary economy and the economy of import, logical consequences of increasingly aggressive globalization, has further accentuated the dependency of the Bedouins on the markets, both as buyers and as producers trying to find a market for their sheep-breeding products.

With the construction of new roads, tourist villages, resorts, and with the arrival of increasingly modern economic and technological means, the Bedouins have stopped being Bedouins. With the lure of government aid, they often turn to sedentary activities thanks to agriculture and new jobs. The use of the jeep rather than mobile phone reveals how much globalization has pervaded these communities, forcing them to the borders of nomadic tradition.

These phenomena lead to encapsulating the Bedouin communities in larger communities and generating new dynamics of fragmentation and social differentiation within them.

The process that more than others seems to mark the life of the Bedouins is sedentarization. This is not irreversible but it can recur in certain periods according to the nature of nomadic breeding. The introduction of wage-earning labour has contributed to constituting mixed economic forms that foresee a link in the bedouin community encapsulated within larger communities, with sectors which may be different from agricultural ones.

The Bedouins are thus involved in a new social-economic mechanism that leads them to new adaptive processes. Periodically they come into contact with the capitalist and industrial production sector, working as wages-earners in oil refineries, gypsum quarries and tourist structures.

Although wage-earning labour entails a tendency to sedentarization, the abandonment of nomadism is never irreversible. Some Bedouin families still reside in the desert although their men are induced to move, for long periods, to the proximity of the industries where they work. Other Bedouin families decide to abandon the traditional tent, and live in stone houses even if they continue to practise sheep breeding.

This tendency to abandon nomadism is not destined, therefore, to produce a definitive sedentarization. Wage-earning labour is seen as a variable component related to the political and social-economic situation in which the Bedouins find themselves.

Wage-earning labour has thus become part of the model of adaptation, based on the combination of breeding, agriculture and caravan-convoy smuggling, a consequence of the instability caused by the constant crises in the Middle East.

The drilling of wells and the use of motor pumps to extract water are all elements that alter the old dynamics of production and the delicate equilibrium between breeding and pastoral farming.

The latter, following the introduction of this new technology, has become an essentially market-oriented activity. These alterations in the production structure in the pastoral field have led to important transformations both in the system of work organization and the logic of the management of social resources. This new orientation has transformed subsistence farming into a profit-oriented system. The change from subsistence breeding to market-oriented breeding tends to transform single Bedouin groups into small "entreprises". This phenomenon has certainly allowed many Bedouin families to integrate successfully into the dynamics of development that characterize the economic life of some countries in this area, but has also produced a process of social differentiation within traditional communities, which is based on non-egalitarian principles of access to the new resources.

The impact produced on the Bedouin society from centralized power structures, through forms of political control and administrative intervention, has exercised a form of conditioning that may be fatal to their independence.

If, on one side, globalization induces the replacing of nomadism with a sedentariness which is funtional to the development of industrial civilization and the nation-State, on the other, it makes nomadism so pervasive as to create new social categories of Bedouins.

The difficulty in combining traditions with the social-economic solicitations that come from globalization creates disruption in the Bedouin communities and disintegration of their identity. In the unstable balance between globalization and tradition, their social and economic life will never be resolved, as we will see, by the definite and irreversible choice between nomadism and sedentarization.

The central government's imposition of new productive activities (mining, petroleum, tourism etc.), playing on facilitations and incentives, has caused a crisis in the old productive system based on breeding and agriculture.

But, paradoxically, the Bedouins end up being the least advantaged by certain aid policies. On the other hand, resolving the problems of the Bedouin communities with policies directed exclusively to reorganizing from the productive point of view, their activity as breeders, is no less deleterious than a welfare policy that creates only deep social alienation.

Productive reorganization cannot but take a similar risk into account.

The negative effects could be contained to the advantage of the positive effects if globalization processes were not assigned by iniquitous political to the automatism of the technology and the market. The Bedouins must, consciously and gradually, become familiar with the new economic and technological means with which they can safeguard and improve their style of production without perverting a millenary culture. Otherwise nomadism risks being assimilated once and for all by the productive reconversions triggered off by the commercialization of the agricultural and sheep-breeding products. To delete these productive forms means altering the old equilibriums which have sustained the tribal organization of the Bedouin community up to the present time.

Globalization, instead of introducing progressive economic-social integration of these communities, favours a differentiation in the timing of economic development and increases social differences, thus furthering fragmentation. It is the Bedouins who pay the highest price, as they see, in the impossibility of amalgamating their social and cultural structure with the one promoted by globalization, the inadequacy of an increasingly market oriented political.



## **BEDOUINS OF SINAI**

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Beside the plain economical implications of a globalized capitalism are emerging social transformations concerning life-styles, cultural systems, territorial organization, and so on. These phenomena are deeply influenced by the increase of mobility and also by the extraordinary progress of means of communication and computers tended to rebuild customs, traditions, identities and needs, in order to level off differences, and create a unique identity model inside the Global Village.

In post-modern societies these changes can be seen as the natural consequence of economical and political choices that, throughout their history, let them shift from a National to a Supranational system where national governments are gradually losing their centrality while horizons widen, distances shorten and borders expand and strengthen. On the contrary, traditional societies are often forced to reckon with advanced economical and cultural structures extraneous to their social and intellectual systems, especially in Arabic countries where the idea of Nation is quite recent.

That is especially true for Bedouin societies whom traditional life style and autonomy is strongly affected on one side by modernization processes, also stimulated by globalization, and on the other side by the centralized decision making process typical of Arab national governments. While the new economy extends needs and consumer models, it doesn't increase the capacity to satisfy them, moreover people doesn't have the right tools to formulate and implement local development processes, nor to understand how to take advantage of the development processes taking place both at a global and at national level. The lack of participation in decision making processes, the absence of governments' policies aimed at developing local capacities, and the scant interest for the preservation of ethnic minorities, determine economic and cultural discrimination of Bedouin societies and threaten their survival and the survival of their traditional life style and cultural traditions. This condition generates a deep estrangement leading these groups to an identity crisis due to the incapability to complain their traditions and rules with needs, values and models imposed by the global system. Consequently, people become consumers while their consciousness together with their social, political and cultural structures remain almost the same, in fact globalization doesn't stimulates the growth of awareness nor the development of traditional structures.<sup>1</sup>

From now on, we will focus the analysis on Sinai Bedouins which condition is representative of all these transformations. Actually in Sinai we come up against a peculiar context. Here the roots of change and loss of identity can be traced back to historical and geographical factors that influenced the transformation of social political and economical traditional structures typical of tribal societies, before the introduction of supranational economic systems and high technologies marking these last few decades.

First of all the Sinai Peninsula has a high strategic value due to its geographical position. Indeed, the Peninsula is land bridge between Africa and Asia, between Egypt and the Arabic Peninsula. It's situated between the Gulf of Suez and the Suez Canal on the west, on the Egyptian side, and the Gulf of Aqaba and the Negev on the east, where it bounds with Israel and the Gaza Strip, and it is bounded by the Mediterranean Sea on the north and by the Red Sea on the south and east.

The Sinai has been inhabited since prehistoric times, but the earliest written information about it dates back to ancient Egyptians, which recorded their explorations there and their expeditions looking for copper and turquoise of which the territory of Sinai is very rich.<sup>2</sup> A road along the Sinai's northern coast served as the principal trade route between Egypt and Palestine for many centuries. After the decline of the Egyptian empire, Nabataeans from Petra controlled the trade routes of the Sinai until they were defeated by the Romans. After 1517 Sinai formed part of the Ottoman Empire.

After the First World War Sinai was administered by Egypt until the Israelis overran the peninsula in the Six-Day War of June 1967. Following the peace agreement reached between Egypt and Israel in 1982, the Sinai Peninsula was returned to Egypt.

Moreover Sinai hold an important role for the three monotheist religious traditions, Judaism, Christianity, and Islam: Israelites wandered there for forty years during their Exodus guided by Moses; during the early Christian period, Sinai became the home of a large number of hermits and ascetics, particularly in the mountainous southern region, where the monastery of St. Catherine served as a pilgrimage site throughout the Middle Ages, even after the Muslim conquest; finally, in 640 AD 'Amr ibn al 'Âs went through Sinai with his army to reach Egypt spreading the new Belief.

The disputes between Egypt and Israel to take possession of the strategic Sinai Peninsula caused high instability in the region accentuating the Bedouins' natural sense of non-belonging to a national community modeled upon principles and rules extraneous to their social and political organization, and mostly unfavorable. Of course the

difficulty to be forced to deal with a national identity dimension felt as extraneous can be common to many minority groups, but it is all the more so for Sinai Bedouins.

Although they are an ethnic minority in comparison with the rest of the Egyptian population, most of the inhabitants of the Sinai Peninsula are Bedouins. They are still organized in some 17 tribes to which individuals are strongly bounded as much as they are connected with the desert. Most of them still earn their living from limited and subsistence agriculture and animal husbandry while a small percentage work in oil or mining industries or is involved in tourism activities.

During the last century Sinai has known the presence of British, Egyptians, Israelis, and, for the last 30 years, of Egyptians again. But in the end no one of them treated with Bedouins. Moreover Egyptian government policy for the region is to "Egyptianize" it without taking account of its distinctiveness, so that their traditions, their customs, their culture and their needs are understated, while they are socially, culturally and economically discriminated and controlled by security measures. Consequently it's easy to understand why Bedouins don't recognize themselves as Egyptians, they don't even call themselves *Egyptians*. Of course this is not only a matter of different cultural traditions and ethnical belonging but also the consequence of an unsuccessful integration attempt. From 1982 onwards Egypt has considered the Sinai question as above all a matter of population settlement. Increasing the population was the way to control and integrate the peninsula. Bedouins use to call people coming from the rest of Egypt to work in Sinai and settle there *Masriyyin* (Egyptians). This people come from the entire Nile Valley following the governmental plan aimed at solving the overpopulation problem along the riverbanks. They use to group and settle together according to their village or governorate of origin, distinguished by accent and economic activity.<sup>3</sup>

For example, in North Sinai, the few factories built in the Al-Arish region, the poorest of the country, provide better-paid jobs primarily for people from the Nile Valley. In the south, settlement grew in tandem with the tourism industry from the 1990s onwards. Actually, the development of South Sinai is based on tourism. The tourism activities are based on private sector investment and controlled by the Tourism Development Authority.<sup>4</sup> TDA started selling land cheaply to private investors without taking in consideration that that land belonged for centuries to Bedouin tribes. In accordance with local customary law, the ownership of the land was founded on the principle of *wada'a al yad*, this expression express in Arabic the action of taking possession of a land. This principle gives to Bedouin tribes or families the property of a virgin land if they settle there and ameliorate its conditions by bringing water, or cultivating it, building something, and so on. As a result of TDA policy Bedouins have been expropriated of the land they used to consider of their own. In addition to this fact people from the Nile Valley hold most jobs both in the hotels and in the informal sector, while most of Bedouins are relegated to the desert and banned from the tourism economy, especially after the bombing attacks in Sharm el Shaykh, Dhahab, Taba and Nuweyba, between 2004 and 2006 that they are believed to be liable for.

So Bedouins inevitably perceive government economic development policies in Sinai to be discriminatory since the only measures directed at them are for the settlement programs which respond primarily to the security objective of controlling them. Indeed, the centralist and authoritarian Egyptian government generally ignores the special characteristics of its provinces and inhabitants. When they're not melted in the majority, both ethnical and religious minority are predominantly marginalized. In some cases international Organizations and NGOs had intervene to help these population in economical development, unfortunately they had not always profitable results. For example the World Food Program in Central Sinai, aimed at providing basic food assistance to families if they abandon their tent to live in stable houses, is failing because it doesn't establishes sustainable conditions for survival for the Bedouins' families involved.<sup>5</sup> On the contrary it is reinforcing their economic dependence weakening their social and economic traditional structures on one side, while on the other side it is endangering the survival of Bedouins' identity and cultural and social heritage.

Moreover, the attempt to integrate the local population into the Egyptian national community imposing as a shared element of nationality the Pharaonic heritage, and ignoring Bedouins' distinctive culture and identity fomented hatred against the brutal policies of the government.<sup>6</sup>

Another severe threat for Bedouin traditions is the restriction of their freedom to move. In addition to the several government efforts to settle Bedouin population to control them and for schooling younger generations, the first reaction of the government to the already mentioned terrorist attacks, was firstly a big wave of repression and arrests against the Bedouin population, and secondly the strengthening of the special military regime imposed in the region after the Camp David agreements that divides the peninsula in four zones controlled by Egypt and a multinational force. Actually the terrorist attacks were carried out by an Islamic group based in North Sinai composed by both Bedouins and Palestinians that are the majority of the population in Rafah, at the Gaza Strip border, and numerous in al-Arish too. Of course this is neither the right place nor the right moment to investigate the reasons and the meaning of these brutal actions that killed almost Egyptians and Bedouins, but they are surely linked to the geopolitical situation and illustrate the region's complex social and political realities. The aspect we want to underline here is the fact that, as a result of these terrorist attacks and of the consequent security policies, the peninsula is now totally armored for its inhabitants whose independence and freedom to move are now limited with greater rigidity. Thus making it impossible for Bedouins to go on living their traditional life style, undermining at the same time the survival of their culture, that symbolize an invaluable ethno-anthropological heritage at high risk of disappearance. Actually, if it's true that Bedouin communities of Sinai never have been only pastoral nomads, on the other side it's true also that they always had to adapt to the difficult conditions of a hostile desert alternating

periods of pastoral nomadism and periods of sedentarization according to their needs, to the environmental conditions, to the presence of flourishing towns or important commercial routs. Bedouins are neither self-sufficient nor closed society from the economical point of view, but they use to build good relationships with their sedentary neighbours to barter their products with basic commodities, but also to find wage labor when they need, and so on. Thus Bedouins traditionally adopted a very flexible economy linked with the possibility to shift between nomadism and sedentarization.<sup>7</sup>

When the possibility to chose runs out Bedouins are forced to sedentarization and to face the rules of a new economy, both because of governmental policies and because of deep economical changes, they are also forced to relate with new activities different from the traditional one such as animal husbandry, farming, trading of their products and woman's handicrafts: carpets, embroidered fabrics and silver jewellery. The problem is that they don't have the tools to conform to these new rules, because of the absence of high and vocational schools and of targeted investments.

The considerable investments from TDA and Tourism Multinational together with the consequent real estate speculation have changed the look of South Sinai. This change means for Bedouins not only the expropriation of their land but also of its resources, first of all water, becoming more and more scarce. On top of that most of jobs are held by "Egyptians" so that in most cases Bedouins, left out from business or relegated to odd jobs and prevented to practice traditional activities, have to emigrate to look elsewhere for a better paid job or, worse still, they turn to illegal activities such as smuggling or growing marihuana and opium.<sup>8</sup>

According to the US State Department 2005 report, "*cannabis is grown year round in the northern and southern Sinai, while opium poppy is grown in the southern Sinai. Poverty, low economic growth, lack of income alternatives and high unemployment rates combined with lack of awareness, have provided the perfect breeding ground for the illicit crop cultivation in Sinai*".<sup>9</sup>

Many young Bedouins get lost between a strong identity tie based on tribal belonging and a modern socio-economical structure different from their cultural context that they are often not able to interpret. The lack of right tools to understand different realities can generate a deep sense of estrangement that can lead them to deny their traditions tempted by the "looseness" of western behaviors, such as sexual freedom and consumerism shown, for instance, by most holiday resorts for mass tourism in South Sinai. Thus giving rise to needs they won't be able to satisfy.

In addition to the mentioned facts it's important to underline that Bedouin's life style it's also influenced by the process of change linked with the diffusion of new means of communications. Camels are being more and more replaced by pick-up and tents by simple temporary housing. At the same time there is a large diffusion of satellite dishes, mobiles and internet which let come inside Bedouin's lives a new idea of time and space, and new behaviors in communicating. Consequently, the gradual disappearance of the social cultural and economical conditions that let survive a considerable tribal society and its traditions and customs for centuries, is leading it to rapid changes causing the gradual but irreversible loss of a precious and unique ethno-anthropological heritage belonging to an ancient land and to a people still keeping its secrets.

<sup>1</sup> Abdel Aziz H., *La globalizzazione contro le identità nazionali* (العولمة في مواجهة الهويات الوطنية), Dar al Hayat, 13/06/2007

<sup>2</sup> Finkelstein, I. and Perevolotsky, A. *Process of sedentarization and nomadization in the history of Sinai and the Negev*, Bulletin of the Amer. Schools of Oriental Research 279, 1990, pp.67-88.

<sup>3</sup> International Crisis Group, *Egypt's Sinai Question. Executive Summary and Recommendations*, Middle East/North Africa Report N.61, 30 January 2007.

<sup>4</sup> *Ibidem*.

<sup>5</sup> *ibid*.

<sup>6</sup> *Ibid*.

<sup>7</sup> Emanuel Marx, *Nomads and Cities: The Development of a Conception*, from: *Shifts and Drifts in Nomadic-Sedentary Relations*, Stefan Leder ed..

<sup>8</sup> See: Hobbs, J.J., *Troubling Fields: The Opium Poppy in Egypt*, Geographical Review, 1998.

<sup>9</sup> US Department of State, *Africa and the Middle East International Narcotics Control Strategy Report*, Bureau of International Narcotics and Law Enforcement Affairs, March 2008. [www.state.gov/p/rls/nrcrpt/2008](http://www.state.gov/p/rls/nrcrpt/2008)

## RE-BRANDING THE LEVANT: CONTESTED HERITAGE AND COLONIAL MODERNITIES IN AMMAN AND DAMASCUS

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### INTRODUCTION

As a region the 'Levant' has been used since the late Middle Ages to describe the Eastern Mediterranean; a 'contact zone' of commerce and trade between the cosmopolitan citizens of the Mediterranean and the Arab traders inland. While the term does not refer to an exclusively Arab or Muslim world it has gone on to inform subsequent Orientalist and colonialist imaginaries, and France and Britain in particular, from colonial times up to the present, have played an important role in the definition and protection of its 'heritage'.

Questions concerning the ownership of heritage are not only contested notions in themselves, but play a crucial part in the ongoing production (and negotiation) of collective social and national identities, especially those concerning civil society and notions of cosmopolitanism (Tunbridge and Ashworth, 1997; Brett, 1996; Graham, 2000; Butler, 2006). For this reason heritage tourism is often loosely categorised according to positionality – be it Western, national, local (non-Western when relating to the global south) and regional.

This paper sets out to explore how these (overlapping and interconnected) interpretations of tourism heritage have changed in recent years by focusing on two very distinct and particular 'Levantine' cities. Damascus, often described as the city with 'the longest history in the world', represents a paradigmatic site of traditional Arab-Levantine heritage; Amman, on the other hand, is popularly perceived as embodying a more recent tradition of Levantine modernity and is of crucial importance in the formation of a postcolonial national identity. These two cities thus symbolize two very different understandings of a 'Levantine' urban and national heritage.

### LEVANTINE HERITAGE TOURISM

As Hazbun (2008) notes tourism – particularly in the Levant region - was initially promoted as an easy means to hard currency and economic development for newly independent states.

In the 1960s and 1970s, governments across the developing world, backed by agencies such as the World Bank and the U.S. Agency for International Development (USAID), pushed tourism as a means to promote market-based economic growth and provide capital for industrialization. These efforts were largely inspired by models derived from modernization theory and development economics in that they focused on large-scale, capital intensive infrastructure projects. (2008, xx)

In a similar way Western models of heritage mapping and management have also been the most influential in conceptualising historical conservation. In particular the establishment of a global definition of what constitutes heritage through bodies such as UNESCO and ICOMOS, and government-commissioned strategy reports from international bodies such as, USAID and the United Nations World Tourism Organisation (UNWTO), heavily influenced by neo-liberal policies of economic development have dominated discussions relating to most forms of heritage conservation and development in Syria and particularly in Jordan.

These practices of global economics have been closely intertwined with general trends in international tourism where, since Thomas Cook offered the first tour in 1869, the Middle East has been offered up as a journey into the European past, an exciting foray into a landscape of pre-society, Antiquity, the Bible, first created by colonial military presence and the work produced by Victorian adventure explorers. Here a Western version of Levantine 'colonial nostalgia' prevails, that has links to other debates surrounding modernity and landscape like the 'urban pastoral' (Harris forthcoming).

However, Steiner (2009) argues that there is evidence that one particular type of heritage tourism 'Classical European centred heritage tourism' is experiencing a fall in demand, and is 'more or less stagnating'. Instead the Middle East tourist destinations undergoing renewed interest are Beirut, Damascus, Sharm El Sheikh and Dubai. According to Steiner the new Arab cities of Dubai and Sharm El Sheikh are examples of symbolic capital, they are 'hyperreal' and lack 'spatial, historical and social embeddedness', while the 'old Arab cities' like Damascus have boomed due to the post 9/11 'intra-Arab travel. However while Jordan's Petra may have peaked, (not according to the Jordan Tourism Board who claim it is the UK's most popular 'must see attraction' according to a 2007 Virgin Travel Insurance survey) touring heritage locations is still a major draw for both European and Arab visitors to Damascus and Amman. In the last ten years Damascus has been transformed by a restorative building boom led by Syrian entrepreneurs, the state, Iraqi exiles and Gulf investors, that is turning many of the Ottoman period Old City 'bayt arabi' houses into a series of boutique hotels, cafes, restaurants and shops. And while the city of Amman cannot claim to be particularly ancient, or 'hyperreal' (barring the huge malls that dot the city) it is also experiencing a new wave of interest in its 1930s origins, a development that has been adopted by the municipality in response to largely private and local initiatives.



This paper argues that local 'rediscoveries' of national (often urban) and regional heritage in both the private and government sphere are on the ascendant and have begun to form a complex relationship with pre-existing Western (colonial, 'universal' and state) imaginations of non-Western history (Smith 2003; Peleggi 2005).

## CHALLENGING THE CONTENT AND CONTEXT OF HERITAGE

### 1. *Western*

Western models, that this paper argues, are largely imbued with different forms of what Gregory (2001) terms 'colonial nostalgia' (see also Bissell, 2005 and Peleggi, 2005). Gregory (2001) contends that (Western) tourism to the 'Orient' is a form of 'colonial nostalgia'. Originally used to refer to colonialists themselves by Rosaldo (1993) 'as a particular kind of nostalgia, often found under imperialism, where people mourn the passing of what they themselves have transformed' Gregory adapts the term to refer to the tourist's nostalgia for colonialism itself and their desire to 're-create and recover the world of late Victorian and Edwardian colonialism as a culture' (2001, 141). However this is just one moment of the nostalgia. The other concerns not only colonialism's 'claims to power but also its claims to knowledge.' (141).

It is unsurprising perhaps then, that both Syria and Jordan are predominantly marketed by Western tour operators as cultural heritage destinations to facilitate this meeting with an idealised 'European' origin past. The historical moments and monuments visited are selective and construct selective tourist histories. And while these histories go as far back through the 'Biblical' Levant to 'Antiquity' and beyond, they are often accessed by contemporary European (and North American) tourists through a late 19<sup>th</sup> and early 20<sup>th</sup> century 'colonial gateway' (where the region is presented as a series of places first discovered or 'opened up' by western archaeologists, adventure explorers. This process is even more strongly embedded in tourist practice through the experience and consumption of the places and routes these travellers stayed in and journeyed through. So how better to travel to Syria or Jordan than in the footsteps of Lawrence, or to stay in a hotel that he once slept in. Even fictitious characters such as 'Indiana Jones' the archetypal cinematic adventurer/explorer of the period lend visitors an important extra depth of experience to the practice and performance of visiting the Levant.

While Lawrence's sojourn in the area represents one of the pivotal moments of the Euro-Arab encounter – for the West at least – it also occurred at a time when other texts, images and imaginations came to the fore such as the Bible (the Victorian version), Richard Burton's translation of *One Thousand and One Nights* (explicit and abridged) and the imaginary of the desert nomad (traveller's accounts). References to these texts run through the descriptions of the countries in brochures and guidebooks and are repeatedly referenced by Western visitors Jordan is the 'Land of the Prophets' or 'Lawrence's Arabia' while tours to Wadi Rum follow the 'footsteps of Lawrence'. Syria is presented in Ministry of Tourism brochures as the 'cradle of civilisation' and 'the land of crusader castles'. (Jacobs, 2005).

Contemporary Western tourism's reliance on selling tours to countries such as Jordan and Syria based on a selective nostalgic history resonates with McClintock's 'anachronistic space' (1995, 30). However the additional use of 'locals' in traditional dress (Jacobs, 2005) to stress the additional pleasure of experiencing a 'living' history that also provides a comforting colonial nostalgia of willing natives – what Bell calls the 'colonised indigence' (2005) – also resonates with Bhabha's (1994) assertion that colonialism 'employed the concept of 'fixity' in the ideological construction of otherness'.

According to Daher (2007), the common terms for the region – Middle East and 'Levant' are very much part of this process – or what he calls an 'colonial or neo-imperial *imagineering* of the region. Furthermore the West is still very active in this 'geopolitical imagineering of regions and creation of geographic categories' exemplified by France's recent promotion of the creation of a Mediterranean partnership of countries under the umbrella of 'Euromed'.

More recently this region, and precisely the geographic region of the Southern Mediterranean encompassing countries such as Syria, Turkey, Lebanon, Egypt, Jordan, Tunis and Algiers, has been inscribed and incorporated through a new European discourse as part of the Euro-Mediterranean space. To understand this neo-liberal geopolitical *imagineering*, it is crucial to analyze the Euromed partnership and collaboration in areas related to the cultural heritage and to heritage tourism and its efforts in construction and production of a new understanding of the region: the new Mediterranean (2007, 7)

### 2. *National/Government*

While heritage is fundamental to the shaping of tourist/Western imaginations, it is also rarely absent from the power networks of modernist nationalism and the administrative arm of national government. In his analysis of the making of the state of Jordan, Massad (2001) notes the importance of heritage to the modern nation state's time-space management of identity.

The nation's commitment to the preservation of a traditional national culture carried through from the past and its project of technological modernization as the present goal to be achieved in the future, place the nation on a synchronic temporal continuum, whereby the nation simultaneously lives its traditional past, its present emergence, and its future modernity as one unmediated moment. It is the nation's subjects who are interpellated differentially to signify these different temporalities of the national – tradition and modernity. (2001; 25).

Daher (2007) argues that the nation states that emerged from the Mandate period in the Eastern Mediterranean were mostly concerned with disassociating themselves from the recent past, particularly the perceived failure of the Ottoman Empire in their desire for legitimacy. In order to achieve this they constructed 'national pasts'.

Such constructed pasts were grounded in a search for distant and ancient origins linked to a disassociation from and varying levels of rejection of the recent past (mainly Ottoman). Due to such ideological, territorial, and cultural transformations, the process of image building and heritage identification and definition became highly contested and problematic especially when it was limited by the physical and political boundaries of the various nation-states and the restrictive and exclusive dogma of nationalism. (2007, 3-4)

These 'national pasts' however omitted vast periods of history and heritage that were not considered to fit in with the current nation-building strategy. Moreover their policies were, according to Massad (2007), unchallenged by local intelligentsia and Arab nationalist scholarship (except for some Marxist approaches) has, like Western Orientalist approaches, failed to adopt a historicized notion of heritage.

Instead, culture and civilization were posited as reified and timeless essences that were separate and separable from the economy, politics and social and power relations, which they constituted. (2007, 4)

Massad suggests this attitude was an attempt to respond to Orientalist worldviews in their colonial context – the common assumption that Arab or Levantine 'culture' was in decline and was therefore lower down the hierarchical scale than European culture. This triggered the newly independent states to adopt strategies such as explaining away many significant cultural and heritage elements as either unrepresentative or a result of a foreign 'import' of a pure culture, or universal. This epistemological affinity 'would inform all their archaeological efforts' (2007, 5). According to Schulze (1987) it made Arab intellectuals construct the thesis that the 18<sup>th</sup> century had been decadent but they were now part of a renaissance of cultural production. This Renaissance (*Nahda*) needed decadence to justify its claim for cultural renewal. It also needed a 'Golden Age' – analogous to European concepts of renaissance.

But even here, the European Orientalists provided precious assistance by explaining to them what the classical Islamic period was, and how it was to be understood and assessed historically. (Schulze 1987, 191-2)

With Jordan sold (in Europe and North America) as somehow belonging to a different and ancient time, existing on the margins of a Western modernity, its capital city, Amman has often been ignored (or even disliked) as an anomaly in this imagined, ancient Middle East. Established as a state capital in the 1930s, when the state of (Trans)Jordan came into being, Western tourists have tended to ignore the city, except in passing (it has the main airport). If it was noticed, it was for the citadel or the Roman amphitheatre and its old name 'Philadelphia'. Jordan's top destinations have been Petra ('discovered' by the Swiss traveller Johann Burckhardt and part of a Levantine tourist itinerary since Thomas Cook) Jarash (the remains of one of the Roman Decapolis cities), and natural landscapes like Wadi Rum – rural sites, often with 'colourful' Bedouin populations that are full of colonial history. Much of Jordan's tourism strategy has encouraged this tourist agenda. As a country that relies on international aid Jordan has, from its inception, followed economic development programmes offered to it by organisations such as USAID, the World Bank, and the Japan International Cooperation Agency (JICA).

Hazbun argues that recent Jordan state tourism policy is still recovering from the 1994 peace treaty with Israel and 'the product of a U.S.-backed effort to transform the region's geopolitics, promote neoliberal economics, and develop transnational links of economic cooperation and interdependence to form the New Middle East' (2008, xxiv). However the promised New Middle East failed to materialise – there was no lasting peace or statehood for Palestinians and most of the mega-projects promoted in this phase, such as a Biblical theme park were never developed.

The New Middle East vision had misrepresented the dynamics that govern tourism economies, contributed to inadequate state policies for tourism promotion, and led to misguided entrepreneurial strategies by much of the private sector. In particular, it led many Jordanians to seek to exploit the short-term opportunities for rent capture by rapidly commodifying Jordanian geography and cultural heritage' (2008, 155)

In 1999, King Abdullah II succeeded his father King Hussein. The discredited 'New Middle East' was replaced by 'Jordan First', which according to Hazbun was an attempt to encourage Jordanians to put their national identity above competing identities such as Palestinian, Arab or Islamic.

In effect Jordan was 're-branding itself as a tourist destination that it hoped could disassociate itself from its unstable neighbours and its strategic partner on the other side of the River Jordan.' (2008, 188)

At the turn of the 21<sup>st</sup> century, concerned by the low number of visitors to the capital (and perhaps more importantly the low number of nights they spent overall in the country) the Greater Amman Municipality embarked on several projects designed to 'renovate' downtown Amman, a crowded, densely populated run of streets from the 1930s and 1940s. The various works involved the erection of 'oriental fountains', the construction of a 'traditional

marketplace' and redecorating shop entrances with 'a traditional Arabesque motif' (*Jordan Times* 2001). For Dieterich (2002) this attempt to recreate a traditional Arab city – or to be more accurate to 'create' since there was none before it in Amman – was an attempt to 'reflect the municipality's vision of how Amman might have been'. As Daher (1999) notes it also represents a process of commodification where an 'oriental' city is conceived as a city that offers itself as a good for consumption in order to facilitate the accumulation of capital (for certain investors)' (Daher, 1999).

However these projects also stalled. Amman's 'Oriental' city plans have failed to develop further. Instead, in recent years this process of commodification has changed direction and the heritage that is currently receiving most focus is the early modernity of the city. Prompted by local private efforts, and then funded and encouraged by Western international organisations such as USAID, the Jordanian Ministry of Tourism and Antiquities (MOTA) and the Amman municipality have begun a program of restoration of early modern (or late Ottoman) building in Amman and other Jordanian cities such as Salt, an architectural heritage that only a few years ago was discounted as irrelevant. In these few short years, the last years of Ottoman rule and the early years of Jordanian statehood have undergone a rehabilitation. The architectural connections of the Ammani coffee shops and cinemas with early Arab nationalist political discourse are no longer seen as a threat to Jordanian national identity. Instead a form of nostalgic modernity (rather than outright colonial) has developed and the state (though MOTA and the Amman municipality) has begun a series of projects that support the current trend to focus on early Amman. One very successful project – carried out in collaboration with Rami Daher is the recent restoration of the 1km long Rainbow Street, one of the oldest streets in the city. New seating spaces have been created that offer views across the city to the citadel, while a new road surface is designed to slow down cars. At its centrepiece is the restoration of the first cinema in Amman, the Rainbow cinema, symbol of cinema as the first truly modern art form. The project's stated aim is to attempt to introduce a 'public sphere' into a city dominated by highways and suburbanized space. Future plans include the creation of 'heritage districts' 'clusters' and walking routes where cultural heritage can be experienced and consumed more directly – by walking, sitting and gazing at views, according to recent presentations at a MOTA conference April 2009.

### 3. Local – the restoration of 'Bilad al-Sham'

While Damascus is also rich in Classical and Islamic monuments it is the amount of surviving domestic Islamic architecture (in particular the merchant houses or *bayt arabis*) that make the city (together with Aleppo) so unique. Approximately half of the 16,832 houses listed in the Ottoman 1900 yearbook were still remaining in 2001 (Weber, 2002)<sup>i</sup>

Ever since the late 19<sup>th</sup> century, middle class Damascenes have been deserting the Old City to move to the former garden and agricultural land to the north and expand into the neighbouring town of Salhiyya. While it started as a means to avoid cholera outbreaks and overcrowding as the population grew, later motivations were more likely to do with a negative association with these grand, decaying merchant houses and their environs, as well as the poor plumbing and lack of car parking spaces. Today however, these families are moving back and European and Arab investors are following.

Applications for restoration licences have increased tenfold and the number of 'renovated' cafes, hotels and restaurants have gone from approximately five in 1998, to over 100 by April 2007. Luxury boutique hotels and nightclubs (now about 10) have followed. The Old City's famous covered markets have also been the focus of intensive property speculation. In his examination of the late 1990s surge in renovation and commercial re-launch of 'grand hotels' (first built in 1882-1910) in south-east Asia and their social construction as historic monuments, Peleggi (2005) argues these hotels make the colonial past available 'as a stage set for consumption practices and, indeed as a consumable spectacle in itself.'

In representing the past in a manner that is physically tangible and yet anachronistic, monumentalised colonial hotels may appear to function in the same way as other products of the heritage industry. In fact they operate in a reversal of the heritage industry's working pattern, which tends to transform the use value of monuments and museums (their being a repository of knowledge and social memory) into economic value through commodification. The monumentalisation of colonial hotels, on the contrary, transforms – or more precisely redoubles – economic value into use value at the same time that it increases marketability by 'restoration'. (2005; 264)

The restored hotels in Damascus however, do not share this colonial past. Furthermore their transformation, however welcomed it might be by Western tourists, often has little to do with a desire to cater for Western appetites, but far more to do with local discourses among the Syrians themselves. As Salamandra (2004) notes, 'The Damascene 'return to the old' is a quintessentially modern phenomenon.... 'Authenticity' in this context is a Syrian construct – a field of contestation rather than an essence. (2004; 4)

Although Amman lacks the cultural heritage of Damascus it is also undergoing its own 'local' version of resurgence of interest in Jordan's early national history and developing identity, accompanied by the transformation of buildings into places for the consumption of (Jordanian) food, clothing and culture. There might not be the abundance of 18<sup>th</sup> century merchant *Bayt Arabis* in Amman, but around the First Circle in Jebel Amman and in Jebel Webdeh the oldest villas from the 1930s, once occupied by British administrators and other city notables, are being restored (and modernised) by Jordanian notable families and speculative businessmen. They are being turned into

chic boutiques, art galleries and cafes, while the Bedouin Tent has become an essential element of design/style for the modern 'Ammani' restaurant.

Whether this occurs in Amman, Damascus (or even in Beirut and Palestine), many of the 'patrons' of these transformations of material artefacts into material culture for consumption are the 'notable families' – an urban elite of a region once known as Bilad al-Sham, who though still immensely powerful and wealthy, have in recent years been largely absent from the (often authoritarian) politics of the region. An urban elite, who through their significant investment in conservation and rehabilitation of local buildings, are, says Daher, now 'reclaiming their position across the region through the appropriation of heritage' (2004).

For Salamandra (2004) in Damascus at least, the reassertion of this elite urban social identity means that 'public culture nostalgia...lies at the heart of social and political contestation in contemporary Damascus (2004, 146). Citing the Hariri, Dabbane and Audi families in Lebanon; the Shomans, Tells, Batainehs or Bisharats in Jordan; the Tourkans, Khouris, Qattans and Husseinis in Palestine and the Ayidis, Jabris and Azems in Syria as examples of this trend, Daher (2004) notes how they are all, significantly members of families that emerged during the 19<sup>th</sup> century. However it is also important to acknowledge that their projects reflect a diversity of interests and a variety of interpretations of 'heritage' across the region and across the generations. While the Hariri family throw up commercial skyscrapers over the old city in Beirut, other families concentrate on restoring old (their own, mostly domestic) houses. There is also a generational divide; older members tend to focus on augmenting their cultural capital through the patronage of art galleries and museums, while younger members prefer neo-liberal influenced renovations that not only become fashionable restaurants and nightclubs, but also make sizeable profits.

#### **4. Regional – Towards Europe or the Gulf?**

Historically Damascus has often served as an important staging post for trade and investment between the south (Arabia) and the (north) east (Europe). As Leila Hudson notes there have been particular periods in history when one has held more influence than the other. In the mid-19<sup>th</sup> century Damascus had primarily gained most of its income as part of the overland Islamic trade region (pilgrimage to Mecca). As she notes a hajj departure was the 'city's grandest spectacle' in itself 'a celebration of exchange and circulation; Damascus as a transit point, Damascus as a production point, Damascus as a way station in the geography of Islam, Damascus as a market' (2008, 48). However, in 1863, the Beirut – Damascus road opened and Damascus experienced the beginning of a shift to the Mediterranean as its primary focus of income and trade. It also led to the commercialization of Damascene agriculture, fluctuating prices, speculation, and exposure to world markets.

The opening of the road reoriented and rescaled long-distance trade from the Islamic orientation of the pilgrimage, with goods carried overland to Mecca and Medina by thousands of small traders making their way from Eastern Europe, Egypt, Anatolia and Iran, to the global orientation of accelerating importation of consumer goods from Europe. (2008, 51)

While 'a French/Syrian elite laid down a broad base for European reorientation and change in the Syrian world.' (2008, 121), by the 20<sup>th</sup> century the British policy of focusing on the Bedouin hinterland and their Arabian links, through Lawrence and gold, says Hudson led to another realignment of Damascus.

The British contribution to Syrian modernity was that much easier because it was destructive rather than constructive....Rather than challenging French dominance in the Levantine cities or the growing German influence on the Ottoman government and its branches, the British worked among the peripheral groups like the Druze, the Kurds and the Bedouin in their rural and desert environs. (2008, 133)

According to Hudson, the advance of the Hashemites and their accession to statehood in the newly created state of Transjordan was a victory aided by technologies and investment in infrastructure that mapped and created new patterns of trade and communication.

The transformation of the Syrian landscape by technologies of transport can be traced through the tramway, which symbolized the modernizing ambitions of Tanzimat Ottoman governors in league with European private capital; through the railroads, which expressed the larger-scale ambitions of European powers to knit together regions and effect economic integration; and ultimately through the automobile, which...drastically undermined the railroads and allowed the desert periphery to develop military and political significance. (2008, 134)

This paper argues that a similar struggle is being expressed through heritage due to its ability to produce revenue and promote particular identities (while ignoring others). Or put another way, it is often how identities are expressed, articulated and contested through the histories of heritage and that leads to the emergence of new identities.

Despite the obvious investment potential in Syria, continued strained relations with the United States (including accusations by the Bush administration in 2005 that Syria was part of the 'Axis of Evil') has, until recently, led to limited Western investment in the city (unlike Amman). With a Democrat government in place in the USA and renewed interest in Syria as a strategic partner in the peace process, this looks set to change. In Europe, the French



Presidency of Sarkozy has also become increasingly interested in Syria and Damascus as Daher notes, often through the cultural field especially under the Euromed development programme. Britain has also made recent political visits and has several large scale investment tourist projects while British newspapers frequently cite Syria and Damascus as the holiday destination for 2009/10. However Arab investment and tourism to Damascus still dominates. According to the Syrian Ministry of Tourism Arab tourists makes up 65 per cent of all visitors while Gulf and Iraqi and Gulf money, has been pouring into the city since September 11, 2001 (and more recently since the Iraq war) and is behind much of the investment in tourist facilities. While much of this consists of a variety of property and business tourism investments (the new Four Seasons hotel in Damascus for example), there is also a growing interest in the assets of heritage. In 2006, Kuwaiti Prince Majed Al Sabah opened a luxury designer store Villa Moda in a restored house in Damascus's Old City's most famous street (A Street called Straight) amid a flurry of attention from the world's fashion media. He went on to forecast this street would become the next 'Bond Street' in terms of cultural cache and the availability luxury designer clothes and goods.

## CONCLUSION

Dominant discourses surrounding heritage have considered it to be an innate material product, passively sitting there waiting to be discovered, restored and presented to tourists as a leisure experience, who are able to consume this experience (through activities such as site visits, staying in an restored building, or eating in a restored house) in return for money. The ways in which this product is created, and by whom, are often left unexplored.

Frow (1991) suggests that 'an irredeemable nostalgia is contained within most modern forms of tourism'. Indeed nostalgia itself is often cited as the primary emotion (or driving force) of modernity or postmodernity. And when it comes to Western tourism to the global South, this nostalgia is often found to have a 'colonial' touch.

Certainly heritage tourism in the 'Levant' would seem to offer just such an experience for Western visitors – everything from the mode of travel to choice of hotel is influenced and based upon accommodation and itineraries that focus on nostalgic colonial-era architecture, memories, images and lifestyles.

McClintock's argument that colonized space is presented as the site of 'prehistory' and the conquering nation is the location of the 'enlightenment', stretches through notions of modernity and its opposites in the colonised world. This paper argues that in contemporary Western heritage tourism to countries like Jordan and Syria these 'anachronistic spaces' are simultaneously reduced to sites/sights on tourist itineraries and expanded to offer the postcolonial modern tourist a new space of neo-colonialism to visit them through. A touristic nostalgic colonial filter creates 'Levantine' cities as anachronistic spaces where 'imperial progress across the space of empire is figured backward in time to an anachronistic moment of prehistory' (McClintock, 2002,40).

As Ashworth and Graham (2005) point out, our knowledge of heritage is situated in particular social and intellectual circumstances that are time-specific. Therefore the meaning of heritage 'can be altered as texts and re-read in changing times, circumstances and constructs of place and scale. Consequently, it is inevitable that such knowledges are also fields of contestation.' (2005; 8) In this way one of the key questions that surround issues of heritage is 'Why a particular interpretation of heritage is promoted, whose interests are advanced or retarded, and in what kind of *milieu* was it conceived and communicated?' (2005; 8).

Current interpretations of heritage as a primarily Western (post)colonial construct cannot adequately explain what happens to this colonial filter when it comes up against these more localised views that, although equally imbued with nostalgia and romance, use a different positionality and are articulated and expressed in particularly different ways for different reasons. For it is local and regional discourses – however internationally informed or influenced by nostalgia – that have begun to offer up different approaches to heritage, a process that is beginning to impact across the board, upon tourist itineraries (Western and non-Western), national strategies, international policies, accommodation choices and imaginations. While we are all familiar with Orientalism and its successors, we also need arguments that can be used to explain and describe the processes involved in the production of local discourses; discourses that are developing, absorbing and incorporating concepts of 'anachronistic' space in a totally different way and for a completely new audience.

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## **CULTURE AND CULTURAL HERITAGE IN LIB DEM CONSTITUTIONALISM**

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### **1. Culture and identity**

If supposing “Constitution” in the strict institutional sense, as main structure, that is to say, as “pillar” of society and source of authority legitimation, “culture” is easily recognizable in accordance with the two meanings mentioned above ( the personal and the community ones ), since it allows to define whole cultural elements, on which personal identity is founded, as well as, those of public one. All things considered, the subject at issue, becomes essential, in order to describe both person ( cultural identity of person himself ) and social class ( cultural identity of a community )<sup>1</sup>. Actually, referring to typical cultural elements can be of any help to prove identity itself and its own legal recognition. In addition to that, it’s useful to remark, that “social customs” reflect a huge part of elements included in the idea of “culture”, as they suggest behaviours connected with traditions, clichés and rules playing an important role to keep order inside a political community. On the contrary, if referring to “normative” contents ( of higher law or superprimary source ) of a constitutional text, it sticks immediately out, a deep interest of the constitutional system in force, in “culture” as far as all its expressions and displays are concerned.

As “legally protected interest” by fundamental law itself, culture becomes “living” nature of society. Any attention, which legal system lavishes on culture, however, is not for the sole use of Lib Dem constitutionalism, assuming that other State’s forms ( such as : the Socialist State, religious systems and the authoritarian State ) already regarded cultural dimension as crucial, to strengthen political “regime” and to carry out any rule, on which Government has to be founded<sup>2</sup>. The preservation of cultural heritage helps to reinforce what in sociological terms has been called “man’s capacity of transcendence. This concept is also relevant in law. “Foresight for life” has been indicated by Ernst Forsthoff as one of the fundamental tasks of the modern social State<sup>3</sup>

### **2. Constitutional propositions**

Early formal recognitions of constitutional interest in “culture” in its several expressions, are to be found in each text of rationalized constitutionalism dated back to the early postwar period. As known, the 1919 Weimar Constitution, hatching a plot of the society it belonged to, included in the article 142 even arts and science: “Arts, science and all their own teaching methods are free. State promotes their free way of thinking and helps their own development” and in the article 150 provided: “Ancient monuments, works of art, beauties of nature and landscape are under State’s protection. It’s up to the Reich, to prevent German cultural heritage from any export abroad”. In that very text, freedom of arts and science was claimed, assuming it also in their teaching methods, and cultural heritage was claimed under protection of public authority indeed.

The Weimar Constitution, bound the State to protect and support arts and science. Lots of constitutions dated back to the early and late postwar period, took cue from those rules, as all countries survived to the war, they were suddenly affected by deep changes inside previous constitutional laws, right according to new leanings of the authority rationalization.

In 1947 during the debate in the Italian Constituent Assembly the President of the Commission for the Constitution Hon. Meuccio Ruini, referring to the insertion of article 9 in the Constitution, thought that the appeal to “a State of culture and protection of the cultural heritage” was necessary and justified and would contribute to qualification of democratic government<sup>4</sup>. One cannot ignore the opinion of those who have pointed to the excessive vagueness of article 9 (Italian Constitution) and to the juridical irrelevance of the question. From this point of view, the vagueness and ambivalence of the text leaves the interpreter free to attribute a predominantly programmatic meaning to it<sup>5</sup>. Nevertheless the Constituent Assembly has approved article 9 as a fundamental rule of the Italian Constitution. The development of culture and research, the protection of the countryside and of the national historical and artistic

<sup>1</sup>Cf. G. Cordini, *Elementi per una teoria giuridica della cittadinanza*, CEDAM, Padova, 1998, p.207 ff.

<sup>2</sup>Cf. N. Assini, G. Cordini, *I beni culturali e paesaggistici*, CEDAM, Padova, 2006, p. 289 ff.

<sup>3</sup>E. Forsthoff, *Der Staat der industriengesellschaft*, Munchen, 1971, 25 ff.

<sup>4</sup>Proceedings of Italian Constituent Assembly, Session 22 december 1947, p. 2570

<sup>5</sup>Cf. V. Crisafulli, *La Costituzione e le sue disposizioni di principio*, Giuffrè, Milan, 1952, 36 ff.

heritage are principles asserted in the Constitution. They give voice to “values” that satisfy the need to make citizens “aware” of their duties concerning the use of the land and the protection of cultural heritage, preparing for them the instruments necessary to achieve socially high goals in these areas. Cultural heritage constitute a patrimony temporarily entrusted to the care of man, who is responsible for the survival and the quality of life of future generations.

### **3. *Constitutional and legal regimes of cultural heritage***

The constitutional regime of cultural heritage, has to be set in the historical background, as constitutional texts in different countries were written. As a result, different terms are used, if looking at constitutional papers. Independently of the terms in use, however, the constitutional interpretation caused a remarkable unanimity in shape and management of cultural heritage itself. Modern constitutionalism, referring to principles on general trends, follows a steady plan, claiming freedom of arts and science and stating preservation of cultural and environmental heritage through an industrious cultural promotion, which can help contemporary mankind to be well-off, just providing all necessary means to be able to realize social useful purposes in lots of fields.

The constitutional principle of free state of opinions, claims the acknowledgements of a wider and granted institutional independence for cultural promotion corporations and high culture institutes, which are assigned important tasks for the protection of national heritage and for the know-hows development. In this sense, it's to stress a deep continuity between liberal classical way of thinking, characterizing the 18<sup>th</sup> century constitutional texts, which already included some principles about freedom of teaching and contemporary social constitutionalism. This last, added other kinds of freedom to the original ones, without changing any context. If anything, the real innovation, were a “dynamic, effective” commitment of public authority and the government's offices. Nowadays, a wider development is remarkable in the recognition of an active role played by private citizens, through the involvement, use and responsibility for management and valorization of cultural heritage ( through sponsorship for image purpose ) and for its own protection too.

In accordance with the common principles of constitutionalism, the inclination for a static outlook on cultural heritage in a community, claiming heritage to be limited to a sole aesthetic contemplation is quite unacceptable. Cultural heritage is always an important “witness of civilization”, but it is of great importance for human promotion too.

The merely “passive” concept of rule, is easily solved, thanks to the achievement of a priority, if not, sole preservative protection of cultural heritage. On one hand, cultural promotion gives public authority an active role and provides it to work as support for a full increase of national heritage. On the other, private citizens are granted with facilities and supports, in the full observance of duties (of proper use, preservation, classification, etc.) affecting their own cultural heritage's enjoyment. Citizens can be imposed new taxes for the protection of public cultural heritage. Cultural promotion doesn't justify the success of a merely commercial concept of cultural heritage and doesn't allow to subject public commitment to a sole heritage yield, without taking in consideration the real background, in which enjoyment is really practicable, and all peculiar aspects of each use, that is to say, of each aspect affecting the quality of cultural heritage placed in contemporary's care. Cultural heritage can turn to property value, according to market criteria, nevertheless, it's always important to refer to all handed down values, that's the reason why, the “incorporeal” component can't be ever separated from the other ones.



## **IDENTITY AND GLOBALIZATION**

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Cultural heritage is a social construction that results from social processes specific to certain times and places. As culture can legitimately be considered a set of processes, artifacts and immaterial legacies (such as languages and traditions), cultural heritage becomes a medium through which identity, power, and society are produced and reproduced. The products of immaterial and material culture have different meanings for individuals and communities. It is the values that they bear that give to some things significance over others and thereby transform some objects and places into “heritage.” Therefore the challenge of conservation is not to conserve for its own sake but, rather, to maintain (and shape) the values embodied by the heritage — with physical intervention or treatment being one of many means toward the action goal. Thanks to a global, integrated approach in which nature meets culture, past meets present, monumental and movable heritage meets the intangible, the protection of cultural heritage, as an expression of living culture, contributes to the development of societies and the building of peace.

In its rich diversity, culture has intrinsic value for development as well as social cohesion and peace. By virtue of its origins and the various influences that have shaped it throughout history, cultural heritage takes different tangible and intangible forms, all of which are invaluable for cultural diversity. Fragile and threatened by natural disasters, man-made conflicts, theft and plundering, cultural heritage is losing its meaning and its transmission to future generations is uncertain. For this reason, the protection and preservation of heritage for future generations constitute ethical imperatives backed up by a series of normative instruments, which have been reinforced by the principle of collective responsibility since the emergence of the notion of world heritage. Cultural diversity is a driving force of development, not only in respect of economic growth, but also as a means of leading a more fulfilling intellectual, emotional, moral and spiritual life. Cultural diversity is thus an asset that is indispensable for poverty reduction and the achievement of sustainable development.

The protection and promotion of tangible and intangible cultural heritage, as an expression of cultural diversity, has been recognized by UNESCO Universal Declaration on Cultural Diversity, 2001, as a driving force in sustainable development, an asset to contribute to poverty reduction, mutual understanding, peace-building. Ineffectiveness or absence of conservation measures are also an effect of the stress experienced by communities undergoing rapid change. Change, whether desired or imposed, entail geographic mobility, social dislocation, and new economic systems. The imbalance between the quasi-static view of management adopted by local authorities and the dynamics of development in societies experiencing rapid transformation becomes unsustainable. Therefore, even though it must be taken into account the role of the national and local Institutions in the preservation of cultural heritage as part of its role in ensuring the stewardship of resources and the sustainability of development, the magnitude of the challenges requires partnerships in action.

International organizations can gather the expertise and leverage the resources needed to address critical problems assessed during the appraisal carried out to formulate the action while there is an expanding role for local non governmental organizations (NGOs) in rebuilding community structure and sharpening of awareness on the value and appropriate use of cultural heritage. NGOs have the freedom and flexibility to innovate, and they are well positioned to engage citizens through sustained outreach, grounded in an understanding of cultural heritage as a vital component of a living community. Public and private institutions involved in the action will be encouraged to view change as a challenge and learn to handle it as a strategy, rather than as a force to be contained.

The most relevant constraints are (i) the unavailability of means and capacities to preserve the local cultural heritage and (ii) the lack of awareness on its value as a tool for socio-cultural-economic development. The needs to preserve tangible and intangible cultural heritage, and to build a sense of ownership of cultural identity, can be answered to by promoting the values of cultural diversity; cross-cultural exchanges by fostering social inclusion, developing local capacities, stimulating debate and cooperation among private and public sector and civil society and including economic activities as a key factor to build self confidence and participation.

The process will answer to cultural heritage management issue by: 1. Building values (data collection/systematization, knowledge sharing, and community involvement), 2. Stimulating interest (awareness-rising), 3. Fostering protection (advocacy and public/private sector involvement), 4. Providing tools for planning and management (capacity development and participation), 5. Undertaking practical intervention (restoration, open air museum, job creation).

These actions are those commonly recognized by international conventions and specialized bodies as key tools for local human and economic development and have as many chances of success as they are implemented within broader national policy framework that allows for further public/private sector involvement and knowledge management. Therefore those actions aimed at foster informal and institutional networking and enhancing national and cross country knowledge sharing will eventually tackle the issue of the cultural isolation and, again, strengthen the general understanding and appreciation of cultural diversity.

The Mediterranean area represents a definite priority in the European agenda aiming to foster mutual relationships and transversal programs, supporting sustainable development processes. To preserve and promote this heritage it is

a must to enhance the links between past and present, reinforce the identity of future generations, and ultimately link these efforts with the creation of cultural and social initiatives and of related income generating opportunities for the local community. Tangier, Morocco with its historical and multicultural Medina, and Siwa, an oasis in the western desert of Egypt, unique human settlement that brings in Egypt the legacy of ancient Berber community, are linked in this paper through their important cultural heritage and eventually lack of strategic planning for the preservation and enhancement of their centennial cultural specificities which created a process of progressive marginalization. Tangier is characterized by a multicultural experience considered its very particular history as city with a international statute and nowadays representing one of the frontiers of migration towards Europe. Concerning the history of Siwa, the political, social and cultural marginalization of Berber communities over the last 500 years and the quest for cultural authenticity, perceived as the basis of collective dignity and freedom, is a world-wide contemporary phenomenon in which Berber intellectuals and activists actively participate, to counteract the often pernicious homogenizing effects of globalization processes on local cultures.

## A HUNGARIAN-TURKISH CULTURAL HERITAGE: SCANDAL AND RECONCILIATION

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A small town – the so-called Szigetvár is located in the Southwestern region of Hungary. Outside of this town the Hungarian – Turkish Friendship Park was created, with two wonderful statues, on shared plinth. This cultural establishment was founded in memory of the Battle of Szigetvár of 1566 which has great European significance. The history of the battle of Hungarian (partly Croatian) and Turkish troops as well as the Hungarian – Turkish Friendship Park created in memory of this battle are unique, or special developments at least.

### *Historical Roots*

Szigetvár marched into the Hungarian and European history due to the siege in 1566 when the Croatian viceroy Miklós Zrínyi, the commander of the castle at the time stopped the 80,000-troop of the Turkish Sultan Suleiman the Magnificent, marching on Vienna, just in front of the walls. Zrínyi defended the castle with his 2,500 soldiers but after the unceasing siege the outer fortress gave it up, and he and his 800 soldiers drew back into the inner castle. On 5<sup>th</sup> September, Suleiman died, of which neither the besieging troop nor the defenders of the castle were aware. After two days as the burning castle could not be held, Zrínyi and his remaining soldiers broke forth from the castle and they were all slaughtered by the Turks – except for three of them.

Zrínyi's heroic death against the ill-proportioned preponderance evoked astonishment and condolence all over Europe. Zrínyi and his soldiers' firmness had historical significance – even if it seemed incredible for the first sight. Although the Turk preponderance won but significant losses hit the offensive party, too. And as the Sultan himself died too, the Turks receded and Vienna eluded. It is no exaggeration to say that the conqueror era of the Turks Empire came to an end with Szigetvár. The French King, Louis XIII's first minister, Prince *Richelieu* exactly expresses Europe's universal acknowledgement and appreciation: „We needed a miracle that the Habsburg Empire would elude, and this miracle happened in Szigetvár. The question was decided here whether the cross or the crescent would leave an indelible mark for centuries on the major parts of Europe.”

### *New Cultural Heritage Is Born*

The Turks drew back their troops from Szigetvár in Autumn, 1566, but they took the town and the region under a long control. Until 122 years, Szigetvár was under Turkish authority, and during this time the Islamic culture established several reminiscences and slowly created the special symbiosis of the Hungarian Christian and the Turkish (as well as the Bosnian) peoples. Szigetvár became a developing town, a flourishing community during the more than one hundred years of Turkish authority: the Turks built *djams*, baths, schools, they opened several handicraft shops, and the intermarriages between the nations became more often. It is not astonishing that after the ultimate leave of the Turks the town has preserved its Turkish past and cultural memories. This uncommon effect reflects to the latest period: to the history of the Park of Hungarian – Turkish Friendship established in 1994. A new cultural heritage is born with this place, which is grandeur of its own and it may rightly draw the distinguished attention of the Mediterranean.

For the 500<sup>th</sup> anniversary of Suleiman I's birth, the Turkey initiated the building of the Park of Hungarian – Turkish Friendship in 1994 and they also subsidized it. The tent of one of the greatest ruler of the Ottoman Empire stood close to this place when he started the siege of the Castle of Sziget (in Hungarian Szigetvár) in 1566. The park was inaugurated by the President of Turkey *Süleyman Demirel*, and the Hungarian Minister of Education *Gábor Fodor*.

The one-acre area located 2 km from the town with 60-meter-long longitudinal and horizontal axes is rented by the Turkish states for a symbolical 1 HUF annual prize (thus practically for free) until 99 years. Turkey built the park on their own money (approximately from 60 million HUF). A triumphal arch-like, perpetually open gate leads into the spectacular group of buildings, while the whole park is surrounded by a waist deep, oriental fence. Sultan

Suleiman's six and half meter tall statue (together with the plinth) stands in the center of the park. On the plinth, Suleiman's two meter tall image in turban from bronze. The portrait captured the old sultan, which is the work of the Turkish sculptor *Metin Jordamur*. Also an ornamental fountain and a marble turbe belong to the park.

As it could be expected, the establishment of the park was not welcomed by everyone in Hungary. The people in Szigetvár finally understood the intention and the initiation of the Turkish: they do not consider the Suleiman's statue simply as a conqueror, or the conqueror of Hungary, but a great historical personality who happened to die in Szigetvár. So they simply wanted to establish a shrine, a memorial park on the money of the Turkish state in the place where he deceased. Basically it can be considered a natural feeling that the Turkish raised the statue and created the park. This is so evident that is not meant to be against the other nation. To mention another example, as we Hungarians did not intend to offend the Russians and the Ukrainians when we asked for permission from the Ukraine to establish a memorial place and to erect a statue in honor of the troops lost in the Battle of Don at the time of the World War II and which was granted.

However, not everyone could cope with the set-up Suleiman statue, which otherwise was a unique event. The people became fastidious in specific intellectual circles in Budapest and elsewhere, and they were at a loss. They clamored about "reason eclipse", astonishment, the ultimate and total fall of Szigetvár, the betrayal of Hungarian interest and point of views, and they apparently demanded the revocation of the park. A small group (of 100-200 persons) protested against the Hungarian state and the local government of Szigetvár, stating that the indulgence of the state and the town is unacceptable. This group travelled to Szigetvár, organized a demonstration, poured oil-paint on the bronze statue, founded a counter-society (Zrínyi Miklós Society Cultivating Historical Memorial Places) then they protested in front of the Turkish Embassy in Budapest. In brief, they strove for making scandal.

Fortunately, the scandal seemed more than it really was. The different protesting actions were solved since Turkey returned the courtesy for the Hungarians. (The friendly act of Hungary and Szigetvár was that they handed over an area to the Turkish and they gave the permission for building a memorial park.) Turkey asked the sculptor of the Suleiman statue to create the other commander's statue in the same style. And of course they provided him with the price of the work of art. After the reasonable decision of Szigetvár's people, the two statues were placed on common plinth, and they were erected not opposite of each other but beside one another. This way Turkey erected a statue for Miklós Zrínyi, the noble opponent in 1997. After 400 years the two excellent commanders are looking at the place of their heroic battle, to the castle of Sziget (namely Szigetvár). The political and ideological tensions, the different skirmish concerning the statue came to an end, the protesting citizens calmed down.

The essence of the Hungarian – Turkish Friendship Park thus the two monumental and astonishing statues were standing together and next to each other became obvious and widely accepted in 1997. This reflects to the historical recognition that reconciliation, relief or even friendship could emerge between two nations, two enemies. There is a possibility for peaceful co-existence and friendship between the nations also in the Mediterranean even if they fought with each other previously. It is not an illusion, or naivety that *shared* cultural heritages can come to existence when the place and role of emotional-impetuous and political approaches is replaced by tranquil and settled value judgment of the history.

#### *The Example of Szigetvár as Philosophical Lesson*

There is not many examples in the history that outstanding personalities of two hostile countries would appear together, next to one another as a piece of art, as a shared cultural memorial place. There is nothing like two commanders who had fought against each other would have got statue with the same style in the same place of memory (for example on the battle field) from the same artist. As far as we know there is nothing comparable to this in Europe, there are few examples in the United States and there is the statue of Magellan and the indigenous warrior who wounded him in the Philippines.

We can allege that Szigetvár has double significance. One curiosity is the complexion of the Battle of Szigetvár itself that Zrínyi undertook the fight in spite of the superior force (2,500 soldiers stood against a troop of 60,000 at least but according to other sources Suleiman's troop number could be 100,000), and he undertook even the heroic death. The other curiosity relates to the statue park. Despite all kinds of incomprehension, protestation and scandal, the monumental statue of the two commanders is still standing, giving meaning to the peaceful cooperation of the two countries who were former enemies.

The curiosity mentioned previously occurred frequently in the history and the conclusions that could be drawn from it are well-known. In conclusion, we are making remarks about the second cultural curiosity now. More precisely, we would like to offer for reconsideration a conclusion with a more profound edification.

In most moderate parlance, it cannot be questioned that the establishment and the operation of the Hungarian – Turkish Friendship Park are not justified: it is not fortunate to assess from daily political and ideological considerations. It is obvious that we must get over with our first reactions, reflections, emotional boundaries. A wider time perspective, the time passing may help healing our old (just or less just) wounds. In connection with this, we may keep in mind the 20<sup>th</sup>-century Hungarian poet *Attila József's* lines (from the poem "By the Danube"): "Out of the blood our fathers shed in battles fows peace / through our remembrance and regard". It is true that the old tensions can be eliminated by thinking and remembering from a historical perspective, and it leads to the real reconciliation. *The shared memorial park in Szigetvár symbolizes this bittersweet process.*

And why can or rather why must the statue of two opponent commanders raised beside each other and why must we remember like this? We can mention one more point of view for this: a more profound argument, a more general conclusion. *Sophocles'* antic tragedy (*Antigone*) warns us: to bury respectfully our deceased is the right of



all of us, which entitles even our enemies. During Creon and Antigone's tragic argument, the tyrant suggests this: „The good and bad cannot win the same fate.” Antigone replies this: „Who knows whether this is the law underground.” Namely, our deceased merits the last honor, the piety and the worthy reminiscence. Antigone says that the god of the underworld Hades judges all the deceased according to the law. The conclusion is not unrealistic: *the humanity, the humaneness*, the human dignity *overwrite everything* as superior and noble values. Everybody is equal in the underworld, and everybody has the same respect. On the basis of humanity, everybody has the right to be buried appropriately and to be enshrined after their death. Independently from their mother tongue, religion, descent, political and ideological tenets.

Thus the gesture and the act of erecting the statue of Suleiman and Zrínyi, the two opposing commanders next to each other is not only understandable and acceptable, but also a quite highly elevated – if it is not the most highly elevated – cultural heritage from the point of view of humanity. And this will be the reason and the significance, the far-reaching general conclusion of the Hungarian – Turkish Friendship Park. Even if many people among us have not recognize this connection, and have not accepted it yet.



## **HERITAGE AS A PUBLIC GOOD BETWEEN ISSUES OF PROFITABILITY AND PROTECTION**

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Thomas Mann wrote in the stories of Joseph: “[...] it sounds strange but property was still owned. As a matter of fact, the main feature of ownership and personal freedom is the right to sell and convey legacy and Joseph maintained in force this kind of right. From then on, throughout Egypt each land belonged to the Pharaoh but at the same time it could be sold and transmitted in inheritance. It’s no accident we talked about a magical change of the idea of ownership just thanks to Joseph’s work [...]].”

Starting from this radical change of the idea of ownership, we can take in consideration each legal issue, just affecting today’s historical artistic heritage of a nation and of the whole human mankind.

The special features of a public property can be easily explained, on the grounds that legal system has identified certain items able to meet particular public interests.

In this respect there are two separate problems, whose solutions seem in apparent contradiction.

On the one hand, the increasingly urgent question about profitability of properties belonging to the historical and artistic heritage, in order to enable their own enhancement, enjoyment and preservation.

But on the other, there is an equally urgent question about preservation and protection of property itself.

The key, allowing a right answer to the questions mentioned above, is perhaps a rethinking of the relationship between public and private sectors.

Generally, it can be assumed, that legal system suggested at first in some European countries was based on the assumption that, public administration had to deal with the performance of public offices and private sector with the completion of public offer by providing additional services, rewarding corporate endeavours and guaranting an income to public administration.

That system failed the correct starting point, that is to say, that public administration had to act in public offices over properties belonging to historical artistic heritage, very soon in fact we witnessed with increasing frequency, the outsourcing of such offices for private operators.

At this moment, when shortage of resources prevents the undertaking of significant actions for protection and enhancement of properties belonging to historical and artistic heritage, we wish a promotion of all initiatives that each territory, with the involvement of private profit and no profit operators, is able to deliver.

This paper means to uncover all cooperation relationships between public and private sectors, including cases study, in order to build right measures to protect and enhance the historical and artistic heritage, never forgetting that the nature of property is and will always remain public, that is to say saved from free availability.

# THE SPOONMAKER'S DIAMOND AS AN IMPORTANT ELEMENT OF THE CULTURAL HERITAGE OF TURKEY

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## Abstract

This study brings to light some features of and the story of the historic loose diamond called Spoonmaker's, Turkey II, or Kaşıkçı Diamond) and its golden frame jewellery of the same name, which includes 49 small diamonds, which is currently on display as Turkish cultural heritage at the Topkapı Palace Museum in İstanbul, including the characteristics of the loose diamond, when and how the loose diamond was brought to the Ottoman imperial treasury, why it was given that name, and when and why it was mounted into jewellery.

This pear-shaped rose-cut loose diamond of 86 carats in weight is the only historic world-famous cut-diamond of the modern Republic of Turkey, which is part of Ottoman imperial (1299-1923) heritage.

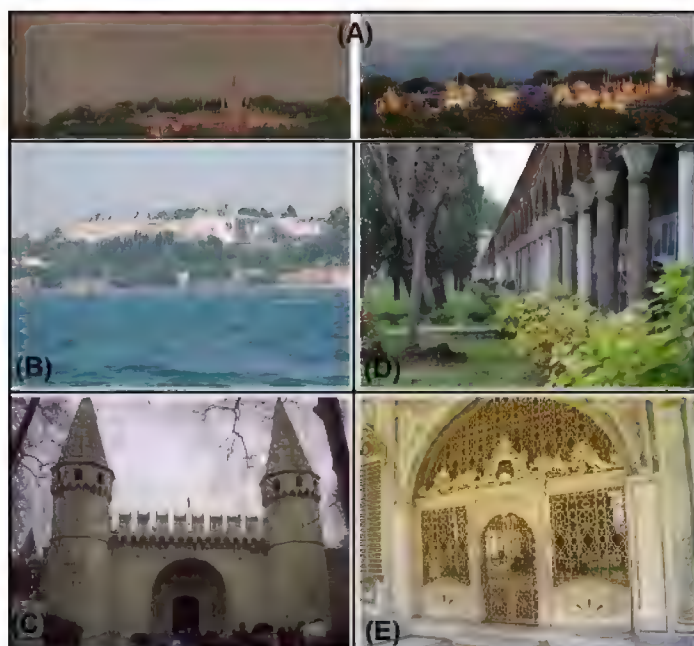
Historically, the Ottoman Sultan Mahmud II was the legal owner of the loose diamond at the beginning of the 19<sup>th</sup> century, and he gave it the name "Spoonmaker's". In addition, the Sultan had the loose diamond mounted on a pear-shaped golden jewellery frame including an additional 49 relatively small diamonds in around 1825. So, the name Spoonmaker's (or the other two names) refers to both the main loose diamond of 86 carats (mounted now) and its antique jewellery of about 38 grams.

The facts and approximate characterizations of both the diamond and its jewellery are disclosed. In addition, the rumours and conflicts derived from three different historical stories are reported and discussed in the paper.

**Keywords:** Gemmological features, Spoonmaker's (Kaşıkçı or Turkey II) Diamond, İstanbul Topkapı Palace Museum, Ottoman-Turkish cultural heritage

## 1. Introduction

The Ottoman Empire was the sovereign between 1299 and 1923 of a large geographical area which comprises southeastern Europe, the Middle East and North Africa. During this period, many precious treasures were brought to the Ottoman imperial treasury by the Ottoman Sultans. After 1923, all the cultural heritage of the Ottoman Empire was assigned to the modern Republic of Turkey. There exist a lot of gem stones and jewellery in this cultural heritage, as well as other materials. Most of them are currently on display at the Topkapı Palace Museum, where the biggest Ottoman jewellery treasury is preserved, in the Sarayburnu vicinity of the Eminönü district of the Sultan Ahmed region of İstanbul. Topkapı Palace, which was constructed in 1470 by the Ottoman Sultan Mehmed II, was not only the residence of the Ottoman Sultans but also the administrative centre of the Ottoman Empire for four centuries (Çetin et al., 2000) (Fig. 1).



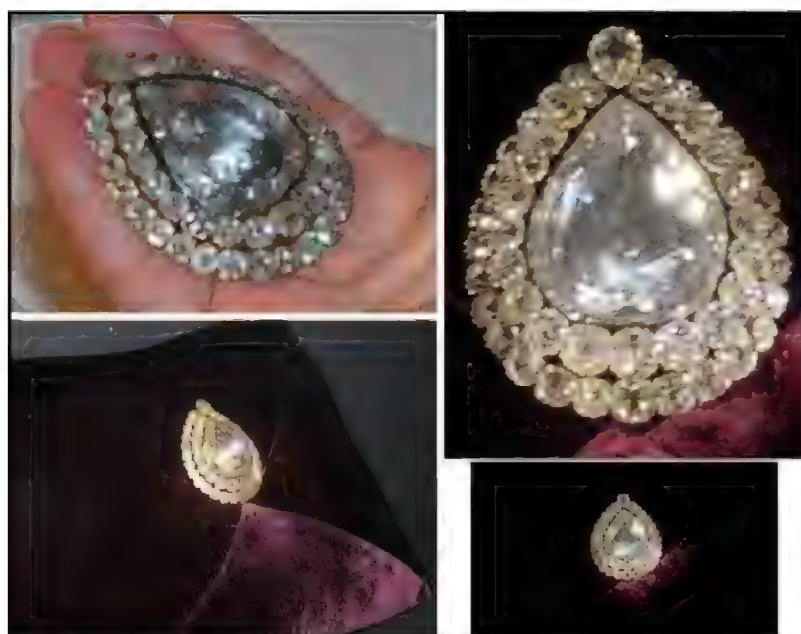
**Fig. 1.** The Topkapı Palace Museum in İstanbul, its panoramic views from a distance (A), from the Bosphorus (B), from the main entrance (C), from the interior (D) and the treasury gate (E), where the biggest Ottoman jewellery treasury is preserved, and in which the Spoonmaker's Diamond and its jewellery are currently on display. The Topkapı Palace was constructed by the Ottoman Sultan Fatih Mehmed, reign between 1451 and 1481.



Today, there are over 150 world-famous cut-diamonds worldwide which are considered 50 carat and over in weight (one carat equals 1/5 gram, used as a weight scale unit of precious stones) (Çetin et al., 2000; Shipley, 2007). At the end of the 19<sup>th</sup> century and the beginning of the 20<sup>th</sup> century, in the sultanate reign of Abdülhamid II (1876-1908), the Ottoman imperial treasury had three historic cut-diamonds over 50 carats in weight (Bruton, 1981). The formal names of these diamonds are Turkey I Diamond (147 ct-loose), Turkey II Diamond or Spoonmaker's Diamond or Kaşıkçı Diamond (86 ct-mounted) and Idol's Eye Diamond (70.2 ct-loose) respectively (Bruton, 1981; Hatipoğlu et al., 2008; Hatipoğlu, 2008A and 2008B; Kendal, 2001; Shipley, 2007). The biggest one (Turkey I Diamond) has been missing since 1908 and there is still not any information about where it is today. The smallest one (Idol's Eye Diamond) was sold at an auction in France in 1909 (Balfour, 2007; Tillander, 1996). The middle one (the Spoonmaker's Diamond), mounted on jewellery of the same name, is the only historic world-famous cut-diamond which is part of Turkish cultural heritage. The name Spoonmaker's (or the other two names) refers to both the main loose diamond of 86 carats (mounted now) and its jewellery of about 38 grams (Fig. 2).

The Spoonmaker's Diamond and its jewellery were assigned to the treasury of the modern Republic of Turkey from the Ottoman imperial heritage in 1923. The Ministry of Culture and Tourism of the Republic of Turkey has given immense importance to it. Hence, it has been specially protected with high security within the display cabinet in the İstanbul Topkapı Palace Museum (Fig. 3).

This paper aims to discuss the approximate characterizations of both the main big diamond mounted at the centre of the jewellery, and of the jewellery itself, in addition to the rumours and conflicts regarding to its history, how and when the diamond was brought to the Ottoman imperial treasury, why it was formally named "Spoonmaker's", and why the loose diamond was mounted into jewellery.



**Fig. 2.** The Spoonmaker's Diamond, or Turkey II, known in Turkish as the Kaşıkçı Diamond. The name refers to both the jewellery of a total weight of 38 gr, including the main diamond and forty-nine historical natural cut-diamonds mounted into a golden frame, and to the loose 86 ct diamond mounted at its centre.



**Fig. 3.** The Spoonmaker's Diamond and its jewellery, currently on display on a claret red color cushion in the İstanbul Topkapı Palace Treasury Showroom (Chamber of Treasure II). It is specially protected within the display cabinet.

## 2. Characterizations and historical stories of the Spoonmaker's (main mounted diamond and jewellery)

### 2.1. Nomenclature

The name in Turkish spelling of the famous historical natural cut-diamond of Turkey's treasury is the Kaşıkçı Diamond. However, it is currently named in the international diamond literature as Spoonmaker's Diamond or Turkey II Diamond (Argenzio, 1974; Balfour, 2007; Bruton, 1981; Kendall, 2001; Lovett, 2002; Shipley, 2007; Tillander, 1996). This diamond was mounted at the centre of a specially-designed golden jewellery frame on the order of the Ottoman Sultan Mahmud II in around 1825 (Fig. 4), according to the Topkapı Palace Museum records. Therefore, according to Mr. İ. Avni Kumuk, who was the first expert to investigate both the diamond and its jewellery in 1968, a unique piece of jewellery of 38 gr was produced (Kumuk, 2006). This piece also includes a lot of historical natural cut-diamonds, one of which is relatively big, and forty-eight of which are smaller (Fig. 2). Thus, the name Spoonmaker's refers to both the special jewellery of 38 gr and the mounted biggest central diamond of 86 ct.

### 2.2. Gemmology

Because of its extreme value and rarity, an exact mineralogical and gemmological investigation of the Spoonmaker's Diamond and the other 49 small diamonds has not yet been possible. However, some non-scientific papers about the Spoonmaker's Diamond and its jewellery have been published by the Ministry of Culture and Tourism of the Republic of Turkey and in related Museum handbooks. In addition, a little information about them is mentioned in some diamond books (Argenzio, 1974; Balfour, 2007; Bruton, 1981; Kendall, 2001; Lovett, 2002; Shipley, 2007; Tillander, 1996) and journal (Önder, 1985).

The first people to investigate the jewellery in detail, with special permission of the related ministry, were Mr. İ. Avni Kumuk, emeritus jeweller and art designer, who worked as staff master in the Mint of the Republic of Turkey, and his colleagues in 1968 (Kumuk, 2006). This investigation was conducted because Mr. Aleksey Kosygin, who was the Prime Minister of the Soviet Union, had speculated that the Spoonmaker's Diamond was not original when he visited the Topkapı Palace Museum on his İstanbul journey in 1968. After the detailed investigation, the ministry declared that the diamond and its jewellery were definitely real and original.

Master Kumuk has not yet published his observations and experiments on the Spoonmaker's Diamond and its jewellery. Nevertheless, the author interviewed him in 2006 to obtain some facts about the gemmological aspects of both the diamonds and its jewellery.

The characterisations mentioned in this study are based on the author's close personal observation studies from 1983 to the present. In addition, the dimensions and facts relating to the diamond's cut are taken from data from master Kumuk's close personal observations and experiments in 1968 (Hatipoğlu, 2008A and 2008B).

#### 2.2.1. Weight

The loose Spoonmaker's Diamond is 86 ct in weight, according to both the Topkapı Palace Museum records and volumetric investigation of the mounted stone by master Kumuk (Kumuk, 2006), which ranks about 60<sup>th</sup> among the worldwide famous cut-diamonds (Balfour, 2007; Shipley, 2007). However, its weight is also reported as 84 ct in some books (Bruton, 1981). It has not been possible to measure the weight of both the main centre stone and its subordinate forty-nine stones exactly because they are mounted on jewellery. Therefore, the weight mentioned here is approximate.

Moreover, it is not known how much the gem rough weight of the initial diamond was before it was cut. However, the initial rough weight of the diamond can be calculated approximately. Firstly, in processing a diamond, the least possible weight loss is taken into consideration. In addition, the outer shape of a diamond such as pear, oval, round, marquis etc. is also adjusted to give the least possible diminution of its rough crystal shape. Considering the diamond cutting equipment and crafts of those years (before about 1825), a diamond would suffer wastages in the ratio of 50-60 % for a one sided rose-cut. Therefore, the gem rough diamond can be estimated to have weighed approximately  $86 \text{ ct} \times 1.55 = 133 \text{ ct}$  initially.

#### 2.2.2. Dimensions

The longest axis of the semi-pear shaped Spoonmaker's Diamond is approximately 3.2 cm. The greatest width of the semi-pear is approximately 1.9 cm. The highest summit of the semi-pear is approximately 0.8 cm (Hatipoğlu, 2008A and 2008B; Kumuk, 2006) (Fig. 2). Thus, the measurements of the Spoonmaker's Diamond are  $3.2 \times 1.9 \times 0.8$ . The specific gravity value for diamonds is 3.52, and  $1 \text{ gr} = 5 \text{ ct}$ .

These approximate measurements give us to following calculations;

$$3.2 \text{ cm} \times 1.9 \text{ cm} \times 0.8 \text{ cm} = 4.8640 \text{ cm}^3 \quad 4.8640 \text{ cm}^3 \times 3.52 \text{ gr/cm}^3 = 17.1213 \text{ gr}$$

$$17.1213 \text{ gr} \times 5 = 85.6065 \text{ ct}$$

#### 2.2.3. Shape and cut

The Spoonmaker's Diamond was shaped as a well-rounded pear, and cut as a flat one sided rose (Fig. 2). The facet sides of the diamond are sharp-edged. Their facets clearly show a vertical alignment of facets. That is, in contrast to its appearance, it was not cut in the same way as primitive brilliant cuts such as the "Mazarin-cut (Old European cut)" or "Peruzzi-cut (Old-Mine cut)" (Argenzio, 1974; Shipley, 2007; Tillander, 1996). In other words, the



diamond is half of an imaginary pear, the interior of the second half of which is empty, and is probably put in a pear shaped tin backed with foil. So, on looking face on at the mounted stone, it gives the illusion that the back part is also diamond. Therefore, the Spoonmaker's Diamond did not have a primitive brilliant shape, and the fact that there is foil under it was confirmed during the study when its back was pierced (Hatipoğlu, 2008A and 2008B; Kumuk, 2006) (Fig. 2).

#### 2.2.4. Color

The real color of the diamond is not known because it is mounted on jewellery. The coloration of a cut diamond, in fact, is seen at the bottom part when one looks at the loose diamond with an angle of 45°. The general color grading system for diamonds is D, E, F for colorless diamonds; G, H, I, J for almost colorless diamonds; K, L, M, N for slightly yellow diamonds; and O, P, Q, R for yellow diamonds (Bruton, 1981).

If it is not looked at from the correct position, the color of a diamond can only be approximately determined. In the light of this gradation, the color of the mounted Spoonmaker's Diamond seems to be near colorless. Therefore, it can be assumed that its color grade is "G" according to GIA (Gemmological Institute of America) gradation, "Rare White" according to CIBJO (The World Jewellery Confederation) gradation, or "Top Wesselton" according to Scand. D.N (Scandinavian Diamond Norm) gradation (Hatipoğlu, 2008A and 2008B) (Fig. 2).

#### 2.2.5. Brightness

The Spoonmaker's Diamond has an excellent brightness when looked at from different angles because its surface polish grade and the cutting ratios of its rose-cut are very good (Hatipoğlu, 2008A and 2008B) (Fig. 2).

#### 2.2.6. Dispersion or Fire

As investigated in 1968 by master Kumuk and his colleagues, the Spoonmaker's Diamond was in reality cut as a one sided rose (Kumuk, 2006), but its fire feature was increased by putting a tin foil with lustre surfaces under the diamond when it was mounted into jewellery (Hatipoğlu, 2008A and 2008B; Kumuk, 2006) (Fig. 2).

#### 2.2.7. Clarity

The Spoonmaker's Diamond seems to be fairly clear when it is looked at from a distance, without any inclusions or external features (Fig. 2). However, a few inclusions could be seen when the stone was examined closely at a magnification of 10x by master Kumuk and his colleagues in 1968 (Kumuk, 2006). Because the stone is mounted its clarity grade cannot be determined exactly. The general clarity grading system for diamonds is IF or LC for extra pure diamonds; VVS<sub>1</sub> and VVS<sub>2</sub> for diamonds with very very small inclusions; VS<sub>1</sub> and VS<sub>2</sub> for diamonds with very small inclusions; SI<sub>1</sub> and SI<sub>2</sub> for diamonds with small inclusions; and P<sub>1</sub>, P<sub>2</sub> and P<sub>3</sub> for diamonds with piquet (Bruton, 1981).

In the light of this gradation, according to GIA gradation, the clarity grade of the Spoonmaker's Diamond can be accepted as "VS<sub>1</sub>" because of its inclusion proportions (Hatipoğlu, 2008A and 2008B).

#### 2.3. Jewellery

The jewellery including the Spoonmaker's Diamond and the other unnamed forty-nine diamonds was produced using a golden alloy in about 1825, during the reign of the Ottoman Sultan Mahmud II (1808 and 1839), but its karat (scale unit used for main gold chemical purity of a golden metal alloy) content is not known because it has not been analysed chemically. However, the total weight of the jewellery, including all diamonds and the gold basement is 38 gr, according to the investigation by master Kumuk and his colleagues in 1968 (Kumuk, 2006). The jewellery was designed as a well-rounded pear or drop, corresponding to the shape of the main Spoonmaker's Diamond. Its dimensions are about 7.0 x 6.0 cm (Hatipoğlu, 2008A and 2008B; Kumuk, 2006).

During the experimental investigation of the jewellery in 1968, master Kumuk and his colleagues drilled a hole in the back of the golden frame of the main centre diamond, despite the fact that this was a destructive and dangerous investigation method for the Spoonmaker's Diamond. This investigation revealed that the dome on the back of the diamond was hollow (Hatipoğlu, 2008A and 2008B; Kumuk, 2006).

The initial well-rounded semi-pear shaped loose diamond was mounted on the jewellery in about 1825. Therefore, it can be understood that the Spoonmaker's Diamond was cut from gem rough material in any period before about 1825. The forty-nine small unnamed diamonds in double orders around the main centre diamond are also mounted in a golden frame. One of them, mounted at the summit of the jewellery, was shaped as a pear in order to match the outer form of the main diamond. The others (48 diamonds) were shaped as round (Fig. 2). They are primitively brilliant cut, but not full-cut. Their shape and cut are most probably Mazarin (Old European) or Peruzzi (Old-Mine) (Argenzio, 1974; Kendall, 2001; Lovett, 2002; Tillander, 1996).

#### 2.4. Historical stories

The answers to some questions about the Spoonmaker's Diamond have not yet been determined, such as, where and when the diamond was cut, where the name of Spoonmaker's comes from, who its first legal owner was, and when and how it was brought into the Ottoman imperial treasury. Therefore, some stories around it have been collected. They are highly different from one another. In fact, these stories are rumours. Moreover, they contain many conflicts

concerning time and people, as well as factual and logical contradictions. According to this, these stories regarding the bringing into the Ottoman imperial treasury of the Spoonmaker's Diamond can be divided into three groups.

#### *2.4.1. The story of the diamond being brought from the İstanbul vicinity*

This story is the one that is in the records of Topkapı Palace and that contemporary historian Reşat Ekrem Koçu mentioned, based upon Belgradi Raşid, who was an 18<sup>th</sup> century historian (Önder, 1985). According to this, a poor man, who was wandering around Eğrikapı garbage dump near İstanbul, found a beautiful transparent stone like glass, in about 1667 or 1669 (Argenzio, 1974). However, how this stone had been dropped there was unknown. Going to a spoon-maker, the poor man exchanged it for two wooden spoons. The spoon-maker sold this stone to a jeweler for ten silver coins (akche; formal monetary unit in the Ottoman Empire). The jeweler showed the glass-like stone to his friends. Then, it was understood that it was a rough gem diamond of great value. They could not agree on the hush money and quarreled. This event was told to their chief. The chief, who was the head jeweler, bought the stone by giving a bag of akches to each of them. Meanwhile, the Grand Vizier of the Ottoman Sultan, Köprülüzade Fazıl Ahmet Pasha heard about it. While the Pasha was planning to obtain the diamond for himself, the incident was heard of by Sultan Mehmed V (reign between 1648 and 1687). The Sultan had the diamond taken to the palace by an imperial order. Then, he gave it to the staff diamond cutter of the palace for cutting and polishing. So, a wonderful cut-diamond of nearly 86 ct in weight appeared (Argenzio, 1974; Lovett, 2002; Önder, 1985).

If this story is accepted to be historically accurate, the questions and conflicts are as follows;

This diamond came to İstanbul at the end of the 17<sup>th</sup> century as rough gem material. The diamond was nearly 133 ct in rough gem weight. According to this, why was such a large stone, which had the appearance of glass, dropped into the Eğrikapı garbage dump near İstanbul? The reasonable logical possibility is that it was brought to İstanbul illegally.

Another matter is the question of why the poor man took it to a spoonmaker instead of a jeweler. The most logical explanation is that this part of the story was made up to be able to give the diamond a connection to a spoonmaker, and therefore explain its name.

Also, why did the jeweler buy a rough stone which he did not know? Why did it cost ten akches although the stone was indeed a diamond? It is logical that this might be a made up story to cover up its being taken to the Ottoman Empire.

According to the story, the rough diamond was cut and polished by the master diamond cutter of the Ottoman Empire. As the shape of the diamond was rose-cut and there was enough knowledge and equipment to shape the stone with that method in İstanbul at the end of 17<sup>th</sup> century, this part of the story seems to be reasonable.

However, this does not explain why its name is Spoonmakers'. One possibility may be that its outer shape is reminiscent of a spoon. In this case, why was it named Spoonmakers' instead of Spoon? The most logical interpretation would be that the diamond cutter's nickname was the spoonmaker and that the formal owner of the diamond, Sultan Mehmed V, may have honored him by giving his name to the diamond.

However, another matter that cannot be explained by this rumour is why and when this loose stone was mounted on the jewellery. As far as can be learnt from the archive information of Topkapı Palace, this loose diamond was mounted with the surrounding 49 cut-diamonds into the jewellery in about 1825 on the orders of Sultan Mahmud II (reign between 1808 and 1839) (Fig. 4). If this is accepted to be true, the loose diamond must have remained in Topkapı Palace for about 130 years, from the end of the 17<sup>th</sup> century to the beginning of the 19<sup>th</sup> century, and must have been kept by ten different Ottoman Sultans. How was it protected in the palace? And why was it not sold or stolen in such a long period, which included the most problematic times of the Ottoman Empire? Also, why did Sultan Mahmud II need to have it made into jewellery? There is no doubt that the logical answers of these questions are difficult.

#### *2.4.2. The story of the diamond being brought from Egypt*

This story is possibly anonymous because its origin is not exactly known. According to this story, the diamond belonged to the mother of the King of France, Louis 16<sup>th</sup>. At the end of the 18<sup>th</sup> century, Napoleon came to power after the French revolution in 1789. Then he sent King Louis 16<sup>th</sup> into exile in Egypt. In that period, Egypt was a governorship dependent on the Ottoman Empire. The governor-general was Kavalalı Mehmed Ali Pasha (reign between 1769 and 1849). The King's mother sent the diamond as a gift to the Pasha on the condition that he would take good care of King Louis 16<sup>th</sup>. Then in about the 1820's, the governor-general Kavalalı Mehmed Ali Pasha rebelled against the central Ottoman Sultanate of Sultan Mahmud II. The Pasha declared war on the central Ottoman Sultanate. He sent the Egyptian Governor's army, whose commander was his son İbrahim Pasha, to Anatolia to make war against the central Ottoman army. Going to a long war, the commander İbrahim Pasha also took the diamond away with him. He thought that the diamond would bring good luck and power, and in addition, if he lost the war, he would give it to the Ottoman Sultanate to atone for himself. However, according to the story, the diamond was lost (or stolen) in the area between the city of Kütahya and the İznik district of Anatolia during the war between the Sultanate and the governorship forces in about 1823. The person who got hold of it showed it to a jeweler in the Grand Bazaar of İstanbul to learn its value. The non-Moslem jeweler saw and understood that it was a priceless stone. However, he told the person who had brought it to him that it was a cheap piece of glass-like stone, without revealing its real value. Moreover, he exchanged it for a pair of wooden spoons. Then, he presented it to the Ottoman Sultan Mahmud II in return for a compromise or benefit.

If this second story is accepted to be true historically accurate, the questions and conflicts are as follows;

This diamond was brought to Istanbul at the beginning of the 19<sup>th</sup> century in about the 1820's. The diamond was probably cut and polished, because a rough stone would not be valuable enough to account for such vital events as discussed in the story. Furthermore, the King's mother surely had the wealth and facilities to process it.

It is completely uncertain what its name was when owned by the King's mother and if it had the same appearance as today. Therefore, even if she had such a diamond, it is ambiguous whether her diamond was the Spoonmaker's Diamond or not.

It would not normally be rational for the commander Ibrahim Pasha to take such an important stone with him during a long war state, the outcome of which was not predictable. The logic here may be to create a story for the bringing of the diamond to Istanbul from Egypt.

Another problem is that a person who did not know its value exchanged it as worthless merchandise for a pair of spoons. As in the previous story, the explanation of the exchange of such a valuable diamond for very cheap spoons may be that it could be a story made up to relate its name to spoons. However, there is again the previous conflict of why its name is "the Spoonmaker's" when it should be "the Spoon"?



**Fig. 4.** The Ottoman Sultan Mahmud II, reign between 1808 and 1830, who was the legal owner of the Spoonmaker's Diamond, and had its jewellery produced in about 1825.

#### 2.4.3. The story of the diamond being brought from Mora and Albania

Just as in the preceding one, in this story, whose origin is not certain and is possibly anonymous, the diamond was purchased by the French ambassador Pikot in India from the Maharajah of Madras in 1774 and was brought to France (Balfour, 2007; Kendall, 2001; Lovett, 2002; Shipley, 2007; Tillander, 1996). It is uncertain if it was cut or rough. Later, somehow the diamond was stolen from Pikot. Sometime later, a large diamond, about the size of the stone taken from Pikot, was put on sale in a nearby auction. A person called Casanova gave a good price for the diamond. Therefore, the diamond became known as the Casanova Lottery Diamond for some time. It had many different owners, and eventually it was bought by Napoleon's mother, Letizia Ramolino. She sold the diamond to a jeweler in 1815 in order to be rescued from the island of Elbe. Then, the diamond was purchased by the adjutant of Tepedelenli Ali Pasha (reign between 1744 and 1822) from the jeweler for 150.000 golden akches in 1819, for the Pasha. In 1820, Tepedelenli Ali Pasha revolted against the Ottoman Sultanate. The Ottoman army of Sultan Mahmud II attacked the Pasha. Eventually, the Pasha was defeated and killed in the war. The stone was added to the Ottoman imperial treasury, along with his entire treasury, by Sultan Mahmud II (Balfour, 2007; Kendall, 2001; Lovett, 2002; Shipley, 2007; Tillander, 1996).

If this last story is accepted to be true historically accurate, the questions and conflicts are as follows;

This diamond was brought to Istanbul at the beginning of the 19<sup>th</sup> century in about the 1820's. The diamond was certainly cut because the adjutant of Tepedelenli Ali Pasha paid 150.000 golden akches for it. However, it is uncertain whether the diamond was cut in India or in France.

There is no illogical point in the story until the point at which it was brought to the Ottoman imperial treasury.

When compared, it can be seen that there are some conflicts between this story and the previous one. The first conflict is that the owners are different. While according to the second story, the owner of the stone was the mother of the French King Louis the 16<sup>th</sup>, in the third story its owner was the mother of Napoleon, who discharged the

French King. The second conflict is the identity of the diamond's owners, who were the Ottoman Governors, before it was taken to the Ottoman imperial treasury. While in the second story it was the Governor-General of Egypt, Kavalali Mehmed Ali Pasha, in the third one its owner was the Governor-General of Mora and Albania, Tepedelenli Ali Pasha. Although the birth places of both the statesmen were in the Balkans, their functional areas were quite far from each other. What they have in common is that although they were both virtuous and useful statesmen, they then rebelled against the Ottoman Sultanate.

#### 2.4.4. Discussion of these stories

When these three stories are examined together, it can be seen that there are some questions about both time intervals and their logic. The similarities and conflicts become clear when they are classified according to the following questions:

**-By which statesman the Kaşıkçı Diamond was first owned and by which Ottoman sultan it was brought to the palace:** In the three stories, the diamond is said to have been owned by three different Ottoman statesmen before it was included in the Ottoman imperial treasury; The Sultan's Grand Vizier Köprülüzade Fazıl Ahmet Pasha, living in İstanbul in the first rumour, the Egyptian Governor-General Kavalali Mehmet Ali Pasha, living in Cairo in the second rumour, and Mora and Albania's Governor-General Tepedelenli Ali Pasha, living in Üsküp in the third one. In the first story, the period was at the end of the 17<sup>th</sup> century and the Sultan of the time was Mehmed IV. In the second and the third rumours, however, the time was at the end of the 18<sup>th</sup> century and beginning of the 19<sup>th</sup> century and the Sultan of the time was Mahmud II. So, there are two important contradictions about the date and the Sultan of the time when the diamond was brought to the palace. Although the dates in the second and third rumours are compatible, the first one belongs to a time that is 130 years and exactly 10 Sultans before Sultan Mahmud II.

**-Whether this diamond was brought to the Ottoman imperial treasury as rough or cut:** According to the first rumour, it is certain that the diamond was a rough gem. On the other hand, according to the other two, it is probable that it was cut when it was brought. It is not plausible for such a big diamond to be found in a garbage dump. If the second and third rumours were true, the original name of the diamond should have been registered before it took the name of Kaşıkçı.

**-Where and by whom the diamond was first cut or shaped:** Such a big diamond cannot be processed by ordinary diamond cutter craftsmen in ordinary places. If the first rumour was true, the stone might have been cut by an Armenian stone master. This means that there was a skilful master who was able to process such a big stone in İstanbul in those years, that is, at the end of the 17<sup>th</sup> century. If the other rumours were true, the stone was brought to Europe firstly as rough material at the end of the 18<sup>th</sup> century, and then it was cut in one of the European countries such as France, Belgium or Italy (Kendall, 2001).

**-Where the diamond was first found as a rough stone:** Before the diamond mines in Brazil were discovered in about the 1720's (Bruton, 1981), the only areas where diamond mines were found were in the continent of Asia, such as in India, Borneo, Sri Lanka and to a lesser extent, Indonesia and some islands attached to Malaysia. In South Africa, which is the third continent, the first diamond mine was discovered in about the 1860's (Bruton, 1981). Thus, the country where this diamond was acquired as a rough stone is certainly India for the first rumour and most probably India for the other two rumours. It can be said that it was probably from the Golconda mine, which was the most famous mine of India, where the biggest diamonds were acquired. It is possible for the second and third rumours that the stone was brought from the diamond mines of Brazil.

**-Why the diamond was named "the Spoonmaker's":** Perhaps this is the most important point to disclose because the answer of when and by whom the name was given to the diamond will be the basis for the true story of the diamond. The fact that it has been in the Turkish treasury for centuries and no name is seriously claimed other than the Turkish one supports the idea that the diamond was brought to İstanbul as a rough stone and was first cut in İstanbul. However, there is also the claim that a stone which disappeared at the end of the 17<sup>th</sup> century and never showed up again and whose name was "Pikot" (Argenzio, 1974; Lovett, 2002; Önder, 1985) may be the Spoonmaker's Diamond itself, and although it was a one-sided rose-cut while being processed, it was closed with an empty tin foil in the same symmetry. Whether the diamond was intended to appear bigger than its real size is also ambiguous, because it is not frequent to make a faking settlement for such a famous diamond. There are two possibilities for the reason that it was named the Spoonmaker's Diamond. The first one is that this stone was first cut by one of the Ottoman Sultans and it is probably named after the nickname of the diamond cutter to honor the craftsman. Secondly, the name "the Spoonmaker's" may have been given to the diamond by coincidence and as an ordinary name.

### 3. Conclusions

The names Spoonmaker's, Turkey II and Kaşıkçı refer to both the main well-rounded pear-shaped rose-cut loose diamond and also the golden jewellery frame including forty-nine small unnamed diamonds. The loose Spoonmaker's Diamond is approximately 86 ct in weight, but its jewellery is 38 gr in weight in total. The jewellery, which is the cultural heritage of the Ottoman Empire, was assigned to the modern Republic of Turkey after 1923, and is currently on display at the Topkapı Palace Museum in İstanbul.

Unfortunately, investigation of the main diamond using modern non-destructive mineralogical devices has not been possible for security reasons. However, some experimental findings relating to the Spoonmaker's Diamond from the



investigation in 1968 carried out with special permission of the related ministry are disclosed in this paper, as the basis for new investigations in the future.

In contrast to its appearance from the front and the side, the Spoonmaker's Diamond does not have a primitive brilliant cut. Its appearance perceptively is a flat one sided rose-cut stone. Possibly in order to make the diamond appear twice the size, the bottom of the diamond was probably set in a foil made from tin, which was a symmetrical rose-shape to the stone. In addition, the bottom including the symmetry was covered with a thin golden plate to disguise the falsity. And also, to support its credibility, the 49 small Mazarin-cut (Old European cut) or Peruzzi-cut (Old-Mine cut) unnamed diamonds were mounted abundantly around it in a double orders golden frame. Thus, the diamond was made into a complex piece of jewellery.

It can be seen that there are many conflicting stories about this diamond, which Turkey can be proud of having as part of the world's shared inheritance, and which is ranked about 60<sup>th</sup> among the worldwide famous cut-diamonds, and that no serious studies have been done to illuminate the facts. Therefore, it is obligatory and necessary that the real story of the Spoonmaker's Diamond should be disclosed, by studying the Ottoman Archives. In order to find out the real story, the period between 1650 and 1850 should be examined and the events of the period should be related to Ottoman jewellery-making. In respect of the stories examined in this paper, the most negative conclusion that might be drawn is that this stone possibly had a dark secret before it came to the Ottoman Treasury, which was obliged to legalize it by giving it a deceptive shape and a different name.

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## WRITING HISTORY THROUGH PLANTS AS A MEANS OF RECOVERING A COMMON CULTURE: THE EXAMPLE OF PACE PROJECT (CULTURE PROGRAMME 2007-2013)

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Not considering Identity and Globalisation as antithetic and contradictory words is one of the striking challenges of the present century. Scientists deal with evidence to document our cultural roots, evidence that can be regarded either as different features or as similarities between people from different countries. Plants are an exceptional medium for observing identity and globalization of food, exploitation of natural resources for different uses, and popular traditions. Since 2007, the team of botanists and archaeologists of the PaCE project have jointly operated in this direction working on the Intercultural Dialogue (European Year 2008) under the call 09/2006 of the **Education, Audiovisual and Culture Executive Agency (EACEA)**. PaCE - 'peace' in Italian, 'rhythm' in English - is the acronym for 'Plants and Culture: seeds of the cultural heritage of Europe', a Culture Programme 2007-2013 project promoting the recovering and dissemination of the green cultural heritage common to Europe.

The project promotes joint actions based on an innovative partnership among universities, research institutions and museums involving countries from North, East, South and West Europe: Italy, Poland, Norway and Spain as partners, were supported by institutions from Bulgaria, England, France, Hungary, Greece, Romania, San Marino, and Turkey. The leaves of box (*Buxus sempervirens* L.) were drawn in the project logo (in the figure): the plant is well known today, mainly because it is excellent for hedging, but its history as a plant useful to humans goes far back. For the Ancient Greeks, box was a symbol of life, sacred to Pluto, while in northern European countries, it is a plant of peace, used in Palm Sunday traditions.



The PaCE project has developed scientific knowledge on the significance of plants in human life, in a diachronical vision, using the language of archaeobotany and ethnobotany. The main researches contribution presented data from the history of useful plants (for example, box-*Buxus*, peach-*Prunus persica*, purslane-*Portulaca oleracea*), key archaeological sites (Rome and its vicinity, Budapest, Ferrara, Pompei), popular practices (leaf-throwing-*Phyllobolia* from ancient Greece) and the value of trees and scented herbs in symbolic and religious sphere. The project has focused on the links between plants and culture in its research and popularization activities: i) a scientific research network and printing of a scientific book <sup>(1)</sup>; ii) a dissemination network for the popularization of this theme, providing plant history and traditions in the languages and cultures of Europe; iii) a web-site and an exhibition realised as joint actions. This project translates intercultural dialogue on the scientific and humanistic cultural heritage of Europe into a concrete action in the form of the PaCE trans-European exhibition, that proves a simple, visible way of getting the message of intercultural dialogue across to people at all levels. A total of 80 posters, realised by research groups from eleven countries, and translated into ten languages, were housed at 23 locations of Europe. The complete list of partners and associated partners, the virtual exhibition and free downloading of scientific papers are available in the project website: [www.plants-culture.unimore.it](http://www.plants-culture.unimore.it).

<sup>(1)</sup> Morel J.-P., A.M. Mercuri (eds), 2009 – Plants and Culture: seeds of the cultural heritage of Europe. Centro Europeo per i Beni Culturali Ravello, Edipuglia Bari.

## **GALILEO'S TELESCOPE - The instrument that changed the world**

**PAOLO GALLUZZI**

The material structure of the only two of Galileo's original telescopes that have passed to us have recently been the object of an in-depth investigation, promoted by the Istituto e Museo di Storia della Scienza in Florence, with the contribution of the Istituto Nazionale di Ottica Applicata, Osservatorio Astrofisico di Arcetri, Istituto Nazionale di Fisica Nucleare e Stazione Sperimentale del Vetro di Murano. This multidisciplinary research has provided important information on the shape, quality and chemical composition of the lenses, on the structure of the tube and on many other technical details of the original instruments.

On the basis of these data, it has been possible to build a replica of one of Galileo's telescopes that perfectly matches the performances of the original artefact. The replica has been used to take astronomical photographs of the celestial phenomena observed by Galileo 400 years ago. In this way a visual archive of what can be seen through the lenses of Galileo's instrument has been created: an extraordinary new resource for scholars.

# PROGETTO IMCMI - ITALIAN MUSEUMS AND CULTURAL MEDITERRANEAN INTEGRATION - ANCIENT MEDITERRANEAN CIVILISATIONS: MULTICULTURAL RELATIONSHIP AND INTEGRATION

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## 1. Introduction

The field of research of ISCIMA, heirs of the great Italian tradition of archaeological studies of the Mediterranean, is naturally orientated towards the cultural relationship among different populations in ancient times and as such constitutes the basis for establishing the importance of cultural heritage in encouraging a multicultural integration.

What renders migration so difficult, and at times even dangerous, is the absence of cultural mediators to help smooth the transition from a prior experience in the country of origin to a new unknown situation in the host country, that is the efforts involved in passing from an established known system and getting used to and accepting a new one.

Acceptance of the new reality becomes easier if what is similar can be identified and related to a previous experience, i.e. something that both share in common and what is different can be considered as a source of cultural enrichment.

In the specific case regarding the cultural relationship with North African migrants, a certain cultural ambivalence exists between European Cultural heritage of colonisation and that of the Protectorate of the Maghreb. This heritage is mostly French but also, in part, Italian and Spanish. If on the one hand the linguistic, pedagogical and institutional heritage supplied north Africans with a certain understanding, of what Europe was like, on the other hand they perceived themselves as being subdued by Europeans in the latter's pursuit of their own economic and political priorities. Nevertheless, actual European economic crisis has revealed the weakness of the European model thereby favouring the spread of the Islamic cultural heritage in an attempt to restore a cultural equilibrium that would give them back their own right of respect that had been denied them by the Europeans.

To set up a relationship on a new basis it is fundamental to know and understand the history that unites all the people who populate the Mediterranean basin and recognise the mutual advantageous relationship that exists among them and which, though often hostile, has, nonetheless, succeeded in creating in "mare nostrum" what is now considered the cradle of world culture.

Bearing this in mind, the Italian museums, which often possess evidence of North African and Near East ancient civilisations can be an excellent meeting place between migrants and their culture of origin and can become workshops where new strategies can be experimented in evaluating this specific archaeological heritage and the benefits it has to offer.

The long history of Italian archaeological collecting has led to the formation of great important collections originating from North Africa and, in particular, Egypt. Interest in the Egyptian civilisation dates back to the end of the IX century B.C. and continues up to the present day and exhibitions on this theme continue to attract the biggest crowds<sup>1</sup>. Egyptology was responsible for introducing into Italian collections objects of "minor" importance linked to other civilisations in North Africa and the Near East. This is often the case with Phoenician artefacts which found their way into such collections soon after the arrival of more precious and better known Egyptian objects. However, interest in this heritage, thanks to the work and impetus of Sabatino Moscati, has over time caused it to become an integral part of Italian culture<sup>2</sup>. It is an example of an avant-garde multicultural path which led to the rediscovery of the importance of Phoenician and Punic findings found in archaeological excavation sites throughout Italy; an awareness that past history cannot be cancelled but on the contrary should be studied and introduced into an educational system to render it more modern and open in its approach to multiracial integration.

With the colonisation of the coastline around the Mediterranean Sea by the Phoenicians, merchants coming from the Near East, an economic and cultural circuit developed in Libya, Tunisia, Malta, Algeria, Italy, Spain, Morocco and Portugal which brought together the population of the two shores of the basin. Italy was subject not only to the Phoenician colonisation but to many others and this particular historical and social experience allowed it to elaborate and assimilate other cultures making them eventually an integral part of its own.

With respect to this it is appropriate to remember again Sabatino Moscati, who speaking about the Italics peoples who lived between the IX –VIII and II-I centuries B.C. said "One could say that there is no appropriate definition to describe the ancient Italics as they cannot be considered Greek or Phoenician or Celts or even Etruscan but at this point things become really complicated"<sup>3</sup>. This Italian ancestral peculiarity, due in part to the geographical position, makes Italy an ideal candidate for a project which has the following objectives.

## 1. Project objectives

➤ To arouse the curiosity and interest of migrants to know, understand and appreciate their cultural heritage, to make them aware of the importance of their cultural identity by showing them evidence of their culture of origin with the aim of establishing a programme of recognition of their cultural roots also outside their own country of origin.

➤ To re-evaluate ancient relationships through the study of archaeological and literary evidence, placing particular emphasis on two aspects: foreign racial integration in ancient times in Egypt; and Phoenician interaction with the people of the Mediterranean, i.e. Greek, Berbers, Etruscans, Italics and Iberians.

➤ To focus attention on places of cult, boundary sanctuaries used not only as meeting places but also places of integration, Menfi, Samos, Delos, Malta, Pyrgi, Cadice, Lixus, the great Mediterranean sanctuaries, but also to consider those less known and of less importance<sup>4</sup>. The documentation relative to the Iberian Peninsula that covers the period from the VIII to VI century B.C. is of particular importance, where it is clear that the Phoenician trade system used a network of sanctuaries distributed along the principle routes of access to the sources of supplies. Places of cult dedicated to Melqart, Astarte and Baal, all closely connected with mining were found in Castulo, Baria and Huelva. The temple found in Baria, probably in honour of Astarte, was associated with the mines of Herrerias in whose surrounding territory a metallurgic plant is known to have existed in the II century B.C.; on the island of Saltés, linked to the area of Huelva<sup>5</sup>, is a sanctuary dedicated to Melqart dating back to the VIII-VII century B.C. Unlike the sanctuaries, the role played by the great temples, such as that in honour of Melqart, in Gades although, no doubt, linked to the supply system of metals, it also played an integral part on a vaster economic scale being situated where three important trade routes converged: the Atlantic route, the Mediterranean route and the Tartessan's route. The economic and political development of Gades from the end of the VI century B.C. was quite different from that of Carthage, seeing that it enjoyed substantial independence both from the North African metropolis and Tyre<sup>6</sup>. Unlike Carthage, who undertook to restructure its own territory and its Mediterranean territorial possessions on imperial lines Gades chose to maintain the political and administrative structure typical of a city-state controlling its regional territory by means of military strongholds (emporium and colonies) and forming alliances with the indigenous cities who governed the natural resources and the commercial routes. One of the most prestigious emporium temples of the Mediterranean is without doubt that of Uni-Astarte- in Pyrgi which gives evidence of the strong links that existed between Caere e Carthage at the end of the VI century B.C. In the sacred area C, which originally comprised a small independent sanctuary, above the altar in granite, an area was closed off to house the gold sheets written in Phoenician and Etruscan and which now are conserved in the Villa Giulia Museum, Rome<sup>7</sup>.

Another example of great interest is the city of Castrum Iuni, an archaeological site situated at the mouth of the river Incastro on the Tyrrhenian coast in the municipality of Ardea, Lazio. It was here that the ruins of an ancient harbour of a stronghold dating back to the Roman epoch and a vast sacred area of an earlier period were found. In the harbour area the amphorae and Punic inscriptions that were found date back to the period IV to III B.C. and are up to now the only examples of its kind found in Central Tyrrhenian<sup>8</sup>.

➤ To form collections of antiques as a demonstration of interest in cultural diversity and for use in multicultural workshops. Unlike the Egyptian collections of worldwide fame such as that of the Egyptian Museum in Turin<sup>9</sup>, or that of the Museum of Florence or Naples<sup>10</sup>, Phoenician findings originating from the Near East and North Africa can also be found in provincial museums, e.g. the glazed ceramics of the Garovaglio collection of Como which comes from Sidon and the Carthaginian topfet stele<sup>11</sup>, which are kept at the Venturini of Massalombarda Museum, Ravenna<sup>12</sup>. Besides, Phoenician coins form part of the most important Italian medal collections, the result of exchange and antique dealings, such as the pieces conserved in the medal collections in museums in Turin, Milan<sup>13</sup>, Florence<sup>14</sup>, Bologna<sup>15</sup>, Rome<sup>16</sup>, the Vatican City and Naples<sup>17</sup>.

In the "Chiesa Nuova" Museum, Assisi is the collection of Mons. Giacinto Tonizza which comprises among other objects coins originating from Cilicia, Phoenicia, Judea e Carthage that span a period from the V to the II century B.C.<sup>18</sup>

Besides Italy boasts public collections of great fame rich with Phoenician finds from local excavations sites. The Whitaker Museum, Mozia is a fine example<sup>19</sup>. It houses the Whitaker donation of the Punic archaeological collection of artefacts coming from the necropolis of Lilibeo, Mozia and Birgi rich in evidence of earlier civilisations such as Sicani, Siculi and Elimi<sup>20</sup>. Furthermore there is the Archaeological Museum "Baglio Anselmi", Trapani, where the wreck of a Phoenician Punic warship of the III century B.C., unique worldwide, is conserved together with pottery, weapons, cannabis indica (hashish used as a tonic by the oarsmen), pig's bones, ropes and riggings that were found on board. Particularly interesting are the nails of this warship which, notwithstanding the fact that the ship had lain on the seabed for over 2300 years, didn't show any signs of rust (oxidation), according to the results of analysis carried out by NASA<sup>21</sup>.

In Sardinia, the Civic Museum, Cabras, conserves a vast collection of archaeological finds found on two of the most important archaeological sites on the peninsula of Sinis: Cuccuru is Arrius, a settlement on the west bank of (the

wetlands of) the lagoon of Cabras and Tharros<sup>22</sup>, an important Phoenician -Punic city, probably the capital city of the territory in the Carthaginian epoch<sup>23</sup>

➤ To study documentation regarding travellers from ancient times to the modern age. Flourishing trade was the obvious and powerful stimulus to travel. The earliest records of exploration of unknown lands is tied to the research for natural resources or the desire to expand one's own territory.

Harkhuf Governor of the southern region of Upper Egypt in whose tomb is depicted his explorations into Nubia a prelude to his military campaign to conquer the region<sup>24</sup>.

The Carthaginian Hannon who, in the V century B.C., was sent in expedition with a fleet and thousands of settlers to establish new settlements or repopulate seven Carthaginian cities along the Atlantic coast of Morocco, probably travelled as far as the Gulf of Guinea. It is believed that Hannon took notes down on tablets of his voyages which were hung up upon his return in the temple of the God Ba'al Hammon<sup>25</sup>.

The Carthaginian General Magon who, according to Ateneo, crossed three times the land without water (the Libyan desert) as far as the Hammon Oasis<sup>26</sup>.

In modern times scientists, archaeologists, collectionists and the military have all contributed to our knowledge and research with traces of antiquities and finds that have over time formed a big part of European archaeological collections. Famous Italians who have worked and travelled in North Africa were, besides, Giovanni Battista Belzoni, acknowledged as the first Italian egyptologist<sup>27</sup>.

The humanist, Ciriaco d'Ancona, who travelled in Greece, the East and in Egypt and is known as the father of Greek epigraphy<sup>28</sup>.

The architect/explorer/geographer Luigi Melchiorre Balugani from Bologna, who between 1765 and 1767 following in the steps of James Bruce, Consul in Algiers, crossed the Mediterranean from Algeria towards the east with the aim of reproducing what they found of classical antiquity during their travels. In 1768 they undertook another expedition along the delta of the river Nile and continued by sea along the eastern coast of the Red Sea. Having arrived at Abyssinia, they went on an excursion to the source of the river Nile stopping at Gondar, where unfortunately Balugani died<sup>29</sup>.

Giacinto Amati, Vincenzo Calza<sup>30</sup>; Carlo Venturini, Consul in Tunis up to 1881<sup>31</sup>; the Jesuit Giorgio Maria Ciaceri, who crossed the whole of Algeria and Tunisia<sup>32</sup>; Lazare Costa, who at the end of 1800, discovered the tophet of El-Hofra on the hillside of the same name, in Constantine in Algeria, on the land of Rousselot while it was being ploughed<sup>33</sup>.

Mons. Giacinto Tonizza, who at the beginning of the last century, was a Franciscan missionary in Egypt, Israel, Syria and Libya and who left his own collection in his will to the Confraternity of the Umbra Province and the Franciscan Order<sup>34</sup>.

The IMCMI project covers a vast field of clearly distinguishable areas of research which, nevertheless, should not be distracted from its final qualifying and binding aim to arouse the curiosity and interest of migrants to know, understand and appreciate their cultural heritage, specially those of school age, through means of suitable didactic activities, workshops and museum exhibitions.

Over the last few years Italian schools have had to face new problematic situations with the increasing number of migrants' children of second generation having at their disposition only the help of foreign experimental models which have proved inadequate. The children born here in Italy of foreigner parents have problems of ethnic and cultural identity which makes them feel excluded from the cultural model of both their country of origin and that of their adopted country and consequently creating an unsatisfactory state of equilibrium. With respect to this aspect it is interesting the didactic course of action undertaken by the Professional Institute "Sisto V" in Rome to emphasize the importance of the role of migrants' children of second generation as cultural mediators both in the family and in the school. From our point of view we would like to stress the fact that to carry out this fundamental role in the best way possible it is essential to start from a unbiased knowledge of the history of their country of origin. In the specific case of the Maghreb, this knowledge should be devoid of any anti-colonial concepts highlighting the mutual advantageous cultural relationship that unites the two shores of the Mediterranean the result of a process of elaboration and acceptance of past history. In this way their distorted view of history, seen only as a sequence of hostilities among civilisations and a continual wave of colonisation, can be corrected.

## 2. The three levels of the Project

- **The physical level:** The setting up of specific multicultural visual itineraries inside museums, documentary videos, books, media and didactic resource material suitable for children of school age. For the same reason as mentioned previously, cultural itineraries to the archaeological sites in the area, where artefacts relevant to North Africa were excavated, and museums, where such objects are kept, should be proposed and organised. An interesting example of a archaeological historical itinerary could be a route that follows in the steps of Hannibal's invasion campaign in Italy.

- **The virtual level:** as regards the use of telematics as a means of breaking the space/time barrier that exists between visitors and museums it not only allows visitors to visit virtually the exhibition halls and get information but also enables them to learn what services are offered by the Museums. Bearing this in mind, nonetheless it would be interesting to propose a clear and well developed project which goes a step further than the creation of a virtual



museum, providing a multimedia(MMS) television programme to be transmitted on the web T.V. network as a way of spreading knowledge and promoting appreciation of the collections dealing with North African artefacts on exhibit in the Italian museums. Broadcasting network to stimulate and promote interest in museum collections throughout Italy and in particular those which house findings originating from North Africa; the dissemination of information of this cultural heritage through activities involving both schools, and migrants present in the territory with the aim of enriching their cultural growth through this process of interaction. The television programme should comprise several episodes such as video news and documentaries which could at a later date be distributed in schools, museums and associations as a means of dissemination. An on-line magazine could be incorporated as part of the programme, where comments can be published regarding topics discussed in the various television episodes. This magazine should be free to download. Last of all, a web site should be set up showing the theme sections and information on the activities and training proposals connected with the project. The website should also act as a means of access to the virtual itineraries of the museums involved in the project which by using multimedia technology will be able to produce the effect of physical presence in the places visited virtually due to a 360 ° panoramic vision, dynamic sequence, and views from different angles which will give a perception of the objects in the halls (visited) placed in their territorial context by using aerial photographs, orthophotographs and maps. Lastly, it might be possible to organise a role play i.e. on the Phoenician colonisation of the West, where the participants being directly and interactively involved can plunge into history as a protagonist and not as a simple spectator.

- **Training and up-to-date courses for:** teachers and museum staff so that they are able to put to benefit the aims of the project in the best way possible.

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## **THE EU PROJECT "CLIMATE FOR CULTURE" - DAMAGE RISK ASSESSMENT, ECONOMIC IMPACT AND MITIGATION STRATEGIES FOR SUSTAINABLE PRESERVATION OF CULTURAL HERITAGE IN THE TIMES OF CLIMATE CHANGE**

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Climate Change is one of the most critical global challenges of our time. This factor, coupled with the increasing demand our society makes on energy and resources, has forced sustainable development to the top of the European political agenda. Scientific research shows that the preservation of the cultural heritage is particularly vulnerable to all three of these factors. As a non-renewable resource of intrinsic importance to our identity, there is a need to develop more effective and efficient sustainable adaptation and mitigation strategies in order to preserve these invaluable cultural assets for the long-term future. More reliable assessments will lead to better prediction models, which in turn will enable preventive measures to be taken, thus reducing energy and the use of resources.

For this purpose and for the first time ever, the CLIMATE FOR CULTURE project will connect completely new high resolution Climate Change evolution scenarios with whole building simulation models to identify the most urgent risks for specific regions. The innovation lies in the elaboration of a more systematically and reliable damage/risk assessment which will be deduced by correlating the projected future climate data (with the spatial resolution of up to 10x10 km grid size) with whole building simulation models and new damage assessment functions. In situ measurements and investigations at cultural heritage sites throughout Europe and the Mediterranean will allow a much more precise and integrated assessment of the real damage impact of climate change on cultural heritage at regional scale. Sustainable (energy and resource efficient) and appropriate mitigation/adaptation strategies, also from previous EU projects, are further developed and applied on the basis of these findings simultaneously.

The CLIMATE FOR CULTURE project will estimate more systematically the damage potential of climate change on European cultural heritage under different climate change scenarios at regional scale. The team consists of 30 multidisciplinary partners from all over Europe and Egypt including leading institutes and experts both in climate modelling and in whole building simulation. One team partner is a member of the International Panel on Climate Change (IPCC) and four partners are members of the standardization body CEN TC 346 (Conservation of Cultural Property).

To raise the awareness of the decision makers what it costs to take actions and what it costs, if we do not take actions to protect cultural heritage the economic impacts and physical risks to European cultural heritage will be identified.

## **DIAGNOSTIC ANALYSIS OF ARCHAEOLOGICAL UNDERWATER FINDS**

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This research is part of the Italian project MESSIAH (methodologies, instruments and innovative applications for underwater archaeology) carried out in the submarine archaeological area of Crotone (Southern Italy). Research focused on study of the various kinds of degradation affecting underwater finds and stone materials aged in an underwater environment. In particular, among the archaeological materials, the following were examined : a) ten fragments of pottery, found during underwater excavations of the Crotone site, including fragments of jars and bricks both probably of Grecian age; b) three marble artifacts from the same underwater site . All finds were kindly made available by the Capo Colonna Museum. Care was taken to select samples of natural and artificial materials such as marbles, granites, biocalcarenes and bricks. The choice of these lithotypes was based on their common presence in underwater archaeological sites, and the Crotone area is characterised by many artefacts composed of these materials. The samples (six per type) were anchored on ceramic tiles with hydraulic mortar and immersed in the protected marine environment of Crotone (Parco Naturale, Capo Rizzuto) at a depth of 7 metres. Procedures for monitoring forms of degradation were carried out in two stages (four months, one year) in order to identify degraded products and to assess physical changes occurring in samples during the period of immersion. Transmitted light optical microscopy and scanning electron microscopy (SEM) were used to study surface biofilms and their interactions with varying stone materials such as brick, marble and granite, that had been immersed in seawater in the Crotone area.

Finally, the samples were analysed by Laser ablation ICP-MS to establish the chemical variations determined by superficial patina.

## ITALIAN STONES: FROM THE PAST TO THE FUTURE

LAURA FIORA & LUCA ALCIATI

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Italian stones are a unique cultural heritage of international standing. Building, architectural, sculptural, bridge, garden, fountain and street and square furnishing stones characterise the identity of the entire country, ensuring a strong bond between natural and human environments. Used as shapeless stones and cobbles, rough-finished or processed into decorative elements and with various surface treatments, stone embraces a background of knowledge and highly specialised craftsmen who are equally a unique heritage of world standing. The quarry is a place of memory that must be documented: sometimes quarries become overgrown and hidden, at other times they are re-used - often as an authentic open-air museum combining nature, traditions and art. The cultural heritage of Italian stone is unique all over the world and inasmuch should be viewed as a combination of the entire stone production cycle, starting from the outcrops in various geological units through to quarry sites that should be valorised as testimony of quarrying in the past, as well as places for the procurement of material to be used in restoration and the production of modern works destined themselves to become historic in the future. Buildings and monuments, rocks in outcrops and quarries should therefore be considered in global terms as a unique cultural heritage. The enormous variety of rocks employed is based on the geology of Italy, that can also be seen through the stones used to build villages and cities, once time of local origin or easily transported by water. This was clearly witnessed in the mid-1900s in Francesco Rodolico's book "The stones of Italian cities" (1953) - a mirror of the Italian geology through buildings and the first petrographic guide to the cities of an entire country. Despite a few inaccuracies, it is still a unique reference work. In recent times, archeometric studies into buildings have extended the sphere of knowledge: it would be in any case necessary to develop a work that summarises the extent of knowledge of the stones found in modern Italian cities, from historic materials through to the recent varieties available on the international market introduced as a replacement for local rocks or chosen for new applications by leading architects (Fiora et al., 2007). As is well-known, stone plays a vital role in the historical and cultural qualification of cities: its use today also assumes new status in urban qualification, such as the reduction of crime risks, as defined by indications in European standards currently being developed (Barboni & Montagna, 2009 with references). Italy until the end of the 1900s was the leading country in the stone sector in terms of its wealth of lithotypes with suitable physical-mechanical and aesthetic properties and the background of practical knowledge concerning quarrying, processing, use and restoration. The production reality today is profoundly different and has changed in view of the environmental problematics that restrict exploitation and the emergence of new producer countries by now authentic giants in the sector (China, India, Brazil, Turkey, Egypt and Iran). Thousands of new varieties are available on the international market and are very competitive with Italian materials, especially as regards the cost factor, and are increasingly used in new constructions and renovation of historic centres. Italian stones are currently characterised by a different situation from region to region, from quarry area to quarry area. First and foremost, there are the traditional rocks used in Italy and abroad for which exploitation activity continues with significant local economic advantages: porphyry (Trentino), Alpine gneiss (for example, "Luserna stone"), marbles (for example, "Carrara", "Lasa" and "Fior di Pesco Carnico"), travertine, limestones such as "Botticino" or "Red Verona", several sandstones such as "Serena stone" and calcarenites such as "Leccese Stone" that are still used on an international scale; their prestige is linked with historical use. Then there are rocks of prevalently local value, such as "Valmalenco serpentine" or "Adamello granite". Other rocks are worked in small quarries and limited quantities, essentially for restoration: for example, "Pietra di Vico" sandstone from Piedmont or some coloured Alpine "marbles". Many rocks are also not worked but are nevertheless very interesting in terms of restoration. Knowledge of these materials must be expanded: examples include the ophycarbonatic rocks of Piedmont such as the "Susa Green Marble", used since the early 1900s not only in Europe but also in Asia and America, the Veneto basalt also used for ornamental purposes, as in monuments in Verona, the so-called selagite vulcanite used to build the city di Volterra and evaporitic rocks such as chalk and anidrite.

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# THE MANAGEMENT OF WOODLANDS WITHIN THE HISTORIC PARKS - THE CASE STUDY OF FOREST STANDS IN VILLA FARNESE AT CAPRAROLA (VITERBO, ITALY)

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## Abstract

In Italy, a number of historic houses with their gardens, parklands and estates may still retain woodlands of varying extent and structure. No forest inventory exists about such woods that provide an important component of the landscape character of many estates. Extensive areas of woodland involve traditional or new techniques of forestry practice but need a new silvicultural scientific approach [1]. Furthermore, the management of woodland of intermediate to smaller size, which may have considerable landscape, conservation and historic values, mostly is a lower priority, especially where resources are limited and economic returns are low (often the case where woodlands are not open to the public). Woodlands within historic parks can be allowed to develop naturally, with little or no management, and give pleasure to the visitors for relaxation and for conservation. However, all woods eventually need some form of management based on a formal planning for a number of reasons: avoidance of fire risk, vandalism and fly tipping, and providing a continuity of wildlife habitat [2]. Also important is to consider their value as well as a complex biological systems with of major interest in terms of bio-ecological diversity and structure of forest stands witnessing an evolutionary process of forest vegetation [3].

The study case analysed concerns the forest stands of Villa Farnese at Caprarola, a relevant cultural heritage in the Viterbo Province, with its XVI century pentagonal Palace, an imposing mansion designed by the architect Vignola. Besides the Italian gardens and the ornamental tree lines also devoted to Vignola, Villa Farnese includes a historical park with a 11 ha woodland divided into three vegetation types: a mixed high forest, a chestnut coppice and a sweet chestnut orchard. During the last century, the expanded to the detriment of the sweet chestnut orchard. More information on forest history and past stand structure and management could come out also from dendrochronological investigations. Both the coppice chestnut the sweet chestnut orchard, are affected by diseases which endanger the vitality of the trees. The conservation and monitoring of the stand structure diversity in the mixed wood and the improvement of health conditions of chestnut stands should be the main goal of sustainable management even in order to open the woodland to the public by creating a didactic path through the different types of forest vegetation. The results are a first contribution to set up a methodology for the quantitative and qualitative analysis of forest stands within historic parks on which to base a formal forest management plan.

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**Keywords:** urban forest inventory, environmental cultural heritage, historic park management, Silver fir

## 1. INTRODUCTION

In Italy, the debate on the conservation of historic gardens and parks usually involves experts of landscape design, landscape history, botany and arboriculture. Arguments concentrate mainly on the conservation of the oldest trees [4]. However, within the parks created around some historic buildings there are small areas covered with either natural or planted forest stands. They give to the green area a naturalistic value which add to the aesthetic and cultural ones, but obviously they need management criteria different than those used for tree rows and formal gardens [5]. As a rule, trees within historic gardens are considered as single individuals. Their safeguard requires the creation of a data base in which each tree is numbered and its botanical attributes are described and their topographic position detected. This procedure follows the instructions of the Central Institute for the Catalogue and Documentation (ICCD) of the Italian Ministry of Culture (Ministero per i Beni e le Attività Culturali). However, when we deal with true, though small, patches of forest which are close to the architectural garden, trees have to be considered as part of a complex biological system that must be preserved with the safeguard of its specific ecosystem features and relationships among the different components. Site conditions and stand structure analysis as well as silvicultural options are effective management tools for such areas and foresters need to be fully involved in the decision making process together with the architect and garden conservators. In addition to historic research on the site, investigations on the past forest management are really significant because the current structure of the forest stands is the result of the past silvicultural treatments [6].

In such context, a research was carried out in order to: 1) inventory the forest types present in the woodland surrounding a famous Renaissance Palace, Villa Farnese, in Caprarola; 2) analyse the structure and dynamics of the mixed forest which covers most of the investigated area, also using dendrochronological techniques; 3) propose a silvicultural management for each forest types.

The results will be used to outline guidelines for the inventory and management of woodlands within historic parks in view of an integration of the current ministerial instructions about the trees. The study aimed at bridging the different scientific approach between forest sciences and cultural heritage fields of research.

## **2. THE GARDENS AND THE PARK OF THE CAPRAROLA FARNESE PALACE** (by Rosalba Cantone)

The Villa Farnese with its gardens, park and woods, it was testified in different times according to archive documents, descriptions of travellers, praising writings, dated back from the end of sixteen century to seventeenth century, and to a rich inventory of drawings, prints and old photographs [7].

The “Lower Gardens” and the “Upper Gardens” of the Caprarola Farnese Palace were planned as a unit together with the earliest project of the monumental complex. They were built in different phases from 1578 to 1625 in the large area behind the palace. They are linked by an upward path transformed, through a series of levelling works and planting several kinds of flowers, shrubs and trees, in order to let the Cardinal and his guests enjoy the beauty of wild nature and of the large surrounding forest landscape. They could also enjoy the fine quality of flowers and plants, and, above all, nature that had been modified by human mind with particular landscape architectural arrangements and fountains construction. The Caprolatto gardens, park and woodland, are the result of several successive contributions and multi-material articles such as marbles, stones, mosaics, statuary complex, water and rich plants. The park has always aroused admiration and real interest in their users at different times, but it was much neglected at the moment when it was given to the Italian State, causing a lot of problems to people in charge of its restoration and maintenance.

The actual living matter of plants and flowers in the Gardens is the effect determined by their natural transformation through the time; in addition, the changing in taste over the centuries have deeply modified the original 16<sup>th</sup> century garden plantation adding several new species, such as camellia, rhododendron, azalea, hydrangea, holly; therefore the design of the of the “Lower Gardens” is different from the original and the hedges are today mixed, (holly lauraceous or holly, laurel and box) and where in the past there was an alley with citrus trees on its sides, today we have pear trees.

In order to get a full knowledge of the original design we studied, first of all, the numerous examples of pictures, i.e. sights, plans and drawings, through which we manage to know in a direct way the real original complex structure of the villa and its gardens.

Such iconographic sources were of a primary importance, especially when comparing also archive documents, related to the establishing of the park and the garden, and to the wall paintings present in the Casina del Piacere (Pleasure Villa) in the Caprolatto complex as well as in Gambera Palace at Villa Lante, located in Bagnaia (a suburb of Viterbo). The different descriptions and eye-witnessing of the travellers, the numerous praising writings and especially the inventory drawn in 1626, on Cardinal Odoardo's death, have allowed to recover the original design of the park and its evolution. In this last document there is a careful description of all pots, flowers and plants present in the gardens at that time, so as very important information can be inferred by the 18<sup>th</sup> century map drawn by Vasi.

Since it was not advisable to transform a situation that had not been changed for a long time, the preference was given to a re-ordering of the structure of the gardens and the woodland by routine maintenance, pruning and trimmings. A further hypothesis is a new plantation of the original species to reconstruct the colours, smells and the shadows of the trees present at the end of sixteenth century.

The original aspect of the Gardens complex, as it was documented by old paintings and descriptions, is now available in the digitalized form.

Another aspect which must be taken into account concerns the restoration of the original range of water supply, necessary to reach the peculiar sight and sound effects of the fountains.

## **3. THE STUDY AREA**

Villa Farnese (XVI century) is located in Caprarola - a small village on the eastern slope of the Mts. Cimini, 50 km north of Rome – and includes a 12,7 ha wide park (Fig. 1) whose altitude ranges from 500 and 600 m a.s.l. In that area, the mean annual temperature is 14,3 °C and the mean annual precipitation exceeds 1000 mm; soils originated from volcanic bedrock and are very deep and fertile; the natural forest vegetation comprises mesophilous hardwood species (*Quercus cerris* L., *Castanea sativa* L., *Ostrya carpinifolia* Scop., *Carpinus betulus* L., *Acer opalus* Mill.). Within the walls of Villa Farnese, just behind the pentagon shaped main building, the Farnese created three Italian gardens and a large woodland with different types of forest and tree plantations. Most of the area is now covered by a mixed silver fir-mesophilous hardwood forest and a sweet chestnut orchard. A very small patch of chestnut coppice is also included in the park. Silver fir (*Abies alba* Mill.) is not autochthonous on the Mts. Cimini and was introduced in 1584 when the cardinal Alessandro Farnese, pope Paul III's nephew, disposed the plantation of 400 seedlings coming from the silver fir Apennine forest of Camaldoli (Tuscany). The forest we see now originated from those seedlings.

In 1941, the Farnesian complex became property of the Italian State. The maintenance of the buildings, the formal gardens and the woodland is currently under the responsibility of the Ministry for Cultural Heritage. In 1982, the Italian Forest Service was requested, by the Catalog Office of the Superintendence, to fill in the Ministerial form for the gardens of Villa Farnese in order to catalog trees, shrubs and ornamental flowers. Cataloging operations began in 1986 by a careful survey of individual units constituting the botanical structure of formal gardens and tree rows and the recording of data concerning the family, species, origin and the number of each plant. In addition to this, soil and

climate characteristics of the area were studied [8] [9]. Any kind of survey has been not realised in the woodland so far. Currently only the Palace and the Italian gardens are open to the public.

#### 4. METHODS

A land-use map of Villa Farnese was created by a topographical survey with a sub meter accuracy GPS. In the mixed forest, all the silver fir trees with diameter at breast height (dbh) above 2,5 cm were inventoried and a sample of 25 total tree height was collected. A tree core was extracted from 29 trees for age determination and dendrochronological analysis. The dbh above 4.5 cm of all trees was then measured in three circular sample plots (SP) (radius = 10 m) representative of the main types of stand structure present in the forest. The topographical position of all the stems within a 10 m x 20 m transect centred on each sample plot was mapped and tree crown projection on the ground measured based on four perpendicular radii in order to draw the stand profile using the Stand Visualization System programme (<http://faculty.washington.faculty.edu/mcgoy/svs/html>). In the chestnut coppice the dbh of all the live sprouts and a sample of 50 tree total heights was measured. In the chestnut orchard the average spacing was surveyed and historical data on production were collected.

#### 5. RESULTS

According to the land use map, the mixed silver fir-mesophilous hardwood forest covers an area of 4,4 ha along the northern and western boundary of Villa Farnese. By the inventory, 503 silver fir trees were counted, with the diameter ranging from 5 to 105 cm and total height from few metres to more than 35 m. By dendrochronological analysis it was possible to assess three main age classes; the oldest tree - which is also one of the biggest - is 160 years old. Therefore, none of the trees planted in 1584 is still alive. The high frequency of trees in the 80-100 year age class showed that the forest was intensively harvested last time about one century ago and that event allowed the silver fir natural regeneration.

Silver fir and chestnut are the dominant species on the stand overlayer along with other species such as small-leaved lime, (*Tilia cordata* Mill.), European hornbeam (*Carpinus betulus* L.), Norway spruce (*Picea abies* Mill.), pubescent oak (*Quercus pubescens* Willd.) and Turkey oak (*Quercus cerris* L.). The latter two species are more frequent in the stands near the Palace. In the lower layer there are species like the manna ash (*Fraxinus ornus* L.), mountain maple (*Acer pseudoplatanus* L.), holly (*Ilex aquifolium* L.), holm oak (*Quercus ilex* L.), black locust (*Robinia pseudoacacia* L.), laurel (*Laurus nobilis* L.), common hazel (*Corylus avellana* L.), common medlar (*Mespilus germanica* L.), mountain elm (*Ulmus glabra* Huds.), wild service tree (*Sorbus torminalis* Crantz), service tree (*Sorbus domestica* L.), wild cherry (*Prunus avium* L.), elderberry (*Sambucus nigra* L.). In the shrub layer are spread butcher's broom (*Ruscus aculeatus* L.), dogwood (*Cornus mas* L.), common hawthorn (*Crataegus monogyna* Jacq.), quince (*Cydonia oblonga* Mill.), wild pear (*Pyrus pyraeaster* L.), ivy (*Hedera helix* L.), spindle (*Euonymus europaeus* L.), Spanish broom (*Spartium junceum* L.), rose (*Rosa* sp.) and species already listed in the lower layer. Among the herbaceous species *Galium aparine* L., *Fragaria viridis* Duchesne, *Polipodium interjectum* Shivas and *Cyclamen hederifolium* Miller, fern (*Pteridium aquilinum* L.) are abundant. Seedlings and saplings of most tree species are present almost everywhere.

The more detailed analysis carried out in the three sample plots demonstrate the heterogeneity of the mixed high-forest as to tree species composition (Tab. I), stand structure and development stage.

The main stand attributes are showed in tab. II. In the sample plot n. 1, silver fir grows with four more hardwoods. The species composition is balanced but silver-fir dominates the over layer and the hardwoods regenerated under the canopy cover (Tab. II). In this part of the forest there are the biggest silver fir trees. In sample plot n. 2, on the contrary, the hardwoods dominate the over layer and silver-fir regenerated very well under their shadow. Some individuals of Norway spruce (*Picea abies* Mill.) - planted during the last century - are also present in the plot but apart to being not autochthonous, that species is not coherent with the original project of the park.

In sample plot n. 3, oaks and hornbeams dominate the stand profile (Tab. 2). Other hardwoods grow in the under layer where also some silver fir saplings live. Silver fir is less present in this part of the forest, probably because it was not planted there in the XVI Century but naturally regenerated under the canopy cover of the hardwoods that spread spontaneously during the past one hundred years. Indeed, the cross tabulation of the current land use map with a 1860 georeferenced map showed that the mixed forest area increased of 1.2 ha to the detriment of the sweet chestnut orchard just in the section of the park where sample plot 3 were located.

More information on forest history and past stand structure and management could come out from dendrochronological analysis about tree age, forest dynamic, and variability in tree growth [10] [11]. The chronology of silver fir of Villa Farnese, formed by 6 single curves, is 145 years old (Fig. 2). There were some difficulties to synchronize all the tree series, especially those showing abundant abrupt growth changes which may be due to climatic influences, but also to the previous management works. The tree rings analysis is a work in progress because biological growth trend must be removed and the comparison with master chronologies network must be performed [12] [13] [14].

The small patch of chestnut coppice stand hardly covers 0,3 ha near the southern boundary of the woodland. The sprouts are 21 years old. Stand density is very high and many dead standing trees - killed by bark cancer (*Cryphonectria parasitica*) and ink disease (*Phytophthora cambivora*) - are present because of the lack of thinnings. Seedlings of silver fir and other shade-tolerant hardwoods are abundant under the cover of the sprouts. The mean height (20,3 m) showed a high soil fertility.

The sweet chestnut orchard covers an area of 6 ha. Tree spacing ranges from 7 m x 8 m to 9 m x 10 m; then, the stand density varies between 110 and 180 trees/ha. There are many trees with big branches killed by bark cancer and several dead standing trees. The total amount of fruit production is 2-2,5 t per hectare and per year, on average.

## 6. DISCUSSION

By the tree diameter frequency analysis, the mixed forest in the park of Villa Farnese can be classified as mixed-unevenaged high forest from silvicultural point of view [15]. The term high forest defines a stands originating from sexual reproduction of tree species whereas a coppice derives from agamic regeneration.

Silver fir and chestnut are the dominant species in the oldest part of the forest whereas in the area more recently invaded by natural vegetation the stand is composed mainly of deciduous oaks and other thermophilous hardwoods that more easily invaded the abandoned portion of chestnut orchard. Under the cover of the adult trees, more shadow tolerant species, mainly silver fir and mesophilous hardwoods, are now regenerating.

As mentioned earlier, silver fir trees currently growing come from the original plantation. That species seem to have successfully reproduced by natural regeneration along several centuries. Unfortunately it was not possible to find out historical documents showing how the stands were managed in the past and excluding the use of new plantations. At the moment we can consider the silver fir a naturalised species under the ecological conditions of the Mts. Cimini and its presence is a precious naturalistic peculiarity of the park.

The future management of the woodland park should have the following main goals: i) to enhance the quality of the current cultural treatments which has been based on occasional, empirical practices so far; ii) to evaluate the possibility to open the forest area to the visitors of the Palace creating a didactic path through the different forest types which are also the most common elements of the Mts. Cimini landscape. Forest planning plays a basic role in attaining these objectives [16] [17]. But, it is to stress that if that green area is to be in the public eye, it is important that the management is based on scientifically sound principles, conforming to suitable silvicultural practices and transparent to people [18]. In particular, for the mixed silver-fir – hardwood forest, four objectives are of greater importance: a) the conservation of the heterogeneous stand structure; b) the stability assessment of the oldest trees along the hypothesized didactical path ; c) the gradual elimination of Norway spruce; d) the continuous monitoring of healthy conditions of silver fir.

What silvicultural criteria apply to a forest is the key decision in order to preserve and enhance the diversity of species and stand structure ( $\alpha$ -diversity) [19]. Systemic silviculture meets those need better than classic timber-oriented silviculture [20]. The most distinctive elements of systemic silviculture is that the treatment does not follow rigid schemes but is adapted to stand structure and supports the natural self-organisation processes that occur in the stand. The key reference points are the natural regeneration and the preservation of a minimum stocking depending on the ecological requirements of the tree species.

Specific management proposals are necessary to improve the health of the coppice stand and the sweet chestnut tree orchard, considering their specific role in the landscape design.

The chestnut coppice covers a much smaller area than the other forest types in the park. The stand has never be thinned and the lack of tree selection has led to an excessive sprout density resulting in a high presence of dead and diseased trees. On the other hand, the dense canopy cover facilitated the regeneration of shade tolerant species like silver fir, holm oak and holly. Thinning remains the most urgent intervention to choose the most vigorous individuals and improve the vitality of the released trees.

The following options can be envisaged for future management of coppice:

- *to maintain the current* silvicultural system, coppicing the stand within ten years after thinning. The stand would be part of the didactical path as an example of the most common type of forest management on the Mts. Cimini;
- *to convert the coppice* into mixed high-forest, by gradually thinning the sprouts on each stumps and allowing the other species to grow into the upper layer. Conversion process would improve the aesthetical characteristics of the stand which is situated very close to the Italian garden.

Taking care of the chestnut trees in the orchard must be also considered a priority of management of the park. First of all assessing their stability and health is essential to protect the safety of visitors as well as architectural canopy structures. Furthermore more healthy trees could guarantee a higher fruit production. Such a goal would be very important to reach as the sale of chestnuts is a main source of funds for the maintenance of the Italian gardens.

The management of these forest types would require also the availability of updated and comprehensive information that can be obtained using geospatial tools (GIS, GPS and remote sensing), to analyze the complex interactions between an architectural design and the natural dynamics of forest vegetation [21].

## 7. CONCLUSIONS

The woodland within Villa Farnese of Caprarola are unique and highly valued resources and they should deserve the same attention as buildings and Italian gardens, but they need to be deeply studied to be managed as forest systems in order to contribute to the complex management of the site. To solve in a sustainable way this goal, the urban forest management tools have to consider the several functions and values carried out by the green area such as historical, cultural, architectural, landscape and biodiversity conservation, social, recreational, fruit production, and so on. The general purpose is to collaborate in a transdisciplinary way to identify new connections and find new insights between different areas of research. Therefore, to take in account the advances in silviculture and urban



forestry researches for the Villa Farnese woodland could be provide further scientific results suitable for a context where forest stands are an integral part of this cultural heritage.

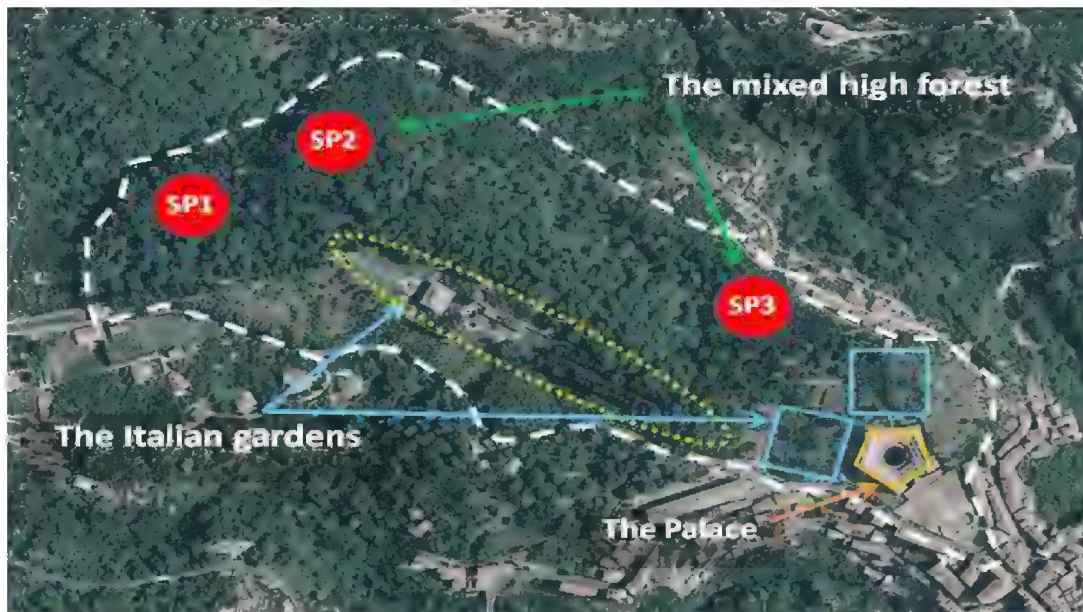
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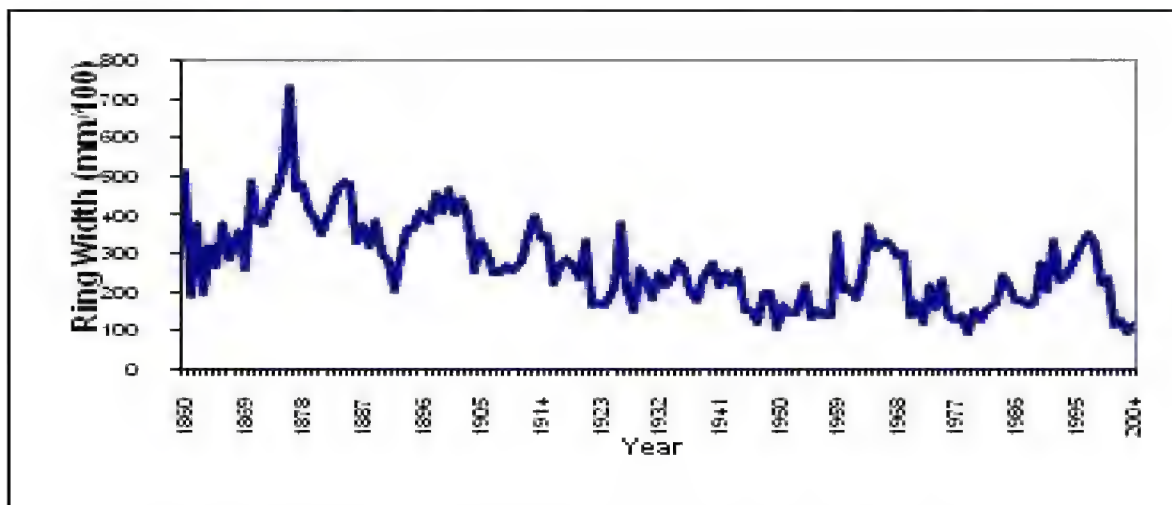
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**Fig. 1** – The historic park of Villa Farnese in Caprarola.



**Fig. 2** – The chronology of silver fir (*Abies alba* Mill.) in the mixed high forest.

**Tab. I** - Percentage of tree species in each experimental plot (SP).

<b>Tree species</b>	<b>SP1 (%)</b>	<b>SP2 (%)</b>	<b>SP3 (%)</b>
<i>Abies alba</i> Mill.	35	47	4
<i>Ilex aquifolium</i> L.	26	4	-
<i>Tilia platyphyllos</i> Scop.	22	6	6
<i>Castanea sativa</i> L.	13	29	-
<i>Corylus avellana</i> L.	4	4	-
<i>Ostrya carpinifolia</i> Scop.	-	6	58
<i>Laurus nobilis</i> L.	-	2	2
<i>Picea abies</i> (L.) Karst.	-	2	-
<i>Quercus pubescens</i> Willd.	-	-	14
<i>Quercus cerris</i> L.	-	-	6
<i>Acer</i> spp.	-	-	6
<i>Fraxinus ornus</i> L.	-	-	2
<i>Sorbus domestica</i> L.	-	-	2

**Tab. II** – Stand attributes in the three sample plots (SP).

<b>SP</b>	<b>Trees/ha</b>	<b>Basal area</b>	<b>Mean dbh</b>	
	<b>(n°)</b>	<b>(m<sup>2</sup> x ha<sup>-1</sup>)</b>	<b>(cm)</b>	<b>(cm)</b>
			stand	silver fir
1	733	59,80	20,0	48,7
2	1766	33,50	14,4	8,5
3	1627	48,00	16,6	15,5

## **THE SOIL AS CULTURAL HERITAGE**

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Soil plays a main and central role for mankind: they are the root of our existence, supporting our feet, our farms, our cities and definitely our cultures. Ancient societies and civilizations have risen, prospered and plowed through a natural substrate called soil. Soils are an environmental resource that needs to be protected for the multiple functions it performs and because it is not renewable in a human time-scale.

Soils act either as a container of information or as sustainers of organic life on earth, from bacteria to humans; they play thus a double role (active and passive) as regards “conservation”. Soils needs protection and should be preserved due to their peculiar characteristics typical of a living, dynamic and vulnerable entity, but, at the same time, they conserve archeological materials giving evidence for our civilization, our cultural heritage and our religions. The physical, chemical and biochemical characterization of soils playing this role can help to understand the conditions and processes that influence decomposition or conservation of buried archaeological materials.

Soils keep records of the past also from the natural point of view; in fact through the analysis of soil profile we can obtain information on the succession of climatic, geologic and biological events.

Moreover, soil formation is a global, complex, bio-abiotic process resulting in the development of unique sequence of layers (horizons), forming a body with its peculiar characteristics (pedon). From this the importance of soil conservation, representing an irreplaceable product of biotic, abiotic and environmental interactions.

The aim of this contribution is to highlight the importance of soil for mankind life and sustainability; in particular we wish to contribute to soil knowledge, respect and awareness with a special attention to the relations occurring between its characteristics and its multiple functions.

## THE CULTURAL EXPLOITATION OF THE OLD WATER WORKS FOR THE REGULATION AND RECLAMATION OF LAKE FUCINO

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### Abstract

Until the middle of the 19th century, Lake Fucino was considered the third largest lake in Italy for surface area. With no natural outlets, the water level frequently rose high enough to flood the surrounding land. To remedy this serious problem, an underground collector, about 6 km long, was constructed in the 1st century AD. Later, due to structural reasons and a lack of maintenance, the entire water work collapsed on itself, returning the lake to its original surface area and bringing back the age-old flooding problem. In the mid-19th century, a new tunnel that partly overlapped the previous one completely drained the lake. At present, both water works are still well preserved, with all their related works, i.e., wells and inclined tunnels, and a new initiative is aiming to restore them for cultural and tourism purposes as part of a project called the Cunicoli di Claudio (Claudius's Tunnels) nature preserve and park.

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### *The Morphological Background*

The Fucino basin covers an area of about 900 km<sup>2</sup> in the Lazio-Abruzzo Apennines and is morphologically dominated by a large flood plain that covers more than 150 km<sup>2</sup>. This depression, whose origin is connected to intense pre- and post-orogenic tectonic phenomena, is delimited by disjunctive or compressive tectonic lines. In geological terms, it is surrounded by a series of, even at times very intensely, fractured and karstified carbonatic meso-cenozoic reliefs and principal faults, which separate it from these, primarily of the direct type with sub-vertical planes and variable displacement for from tens to hundreds of metres. As revealed by geophysical prospecting, the carbonates are lowered below the surface by a series of stepped fault blocks. In addition, this structure was rapidly filled with slope and river-lake detritic sediments, which are several hundreds of metres thick and in some sections exceed 1,000 m (Giraudi, 1994). At its edges their reciprocal contact is made heterogeneous by significant interdigitation. The hydrogeological situation is similarly complex with regional carbonatic aquifers that are drained at their base by high-capacity springs but that also interact with the alluvial water tables and with the surface hydrographic system (Boni et al., 1986; Celico, 1983).

In any case, the most striking morphological aspect is related to the complete absence of a surface outlet and, for this reason, in addition to evaporation, the waters contained in this endorheic basin are only drained through the discontinuous operation of karstic sinkholes at its edges. It has been established (Giraudi et al., 2001) that historically their location, not far from Luco dei Marsi in the foothills of the Mount Salviano in the Pedogna or Petogna area was known about, as was their operation, albeit for specific characteristics, not the least of which the presence of significant sediments whose absorption capacity was, in any case, limited, probably little more than 1 m<sup>3</sup>/sec. (Brisse & De Rotrou, 1883). It was clear that this absorption area, with two or three points of concentration, began operating when the water level reached high levels and, for this reason, the idea of assisting their drainage appeared logical and functional, with the goal of regulating and reclaiming the land involved through the construction of direct subterranean canals at that site.

The studies performed have established that a first, five-metre-wide channel of unknown depth, was filled with sediments whose roof contains a horizon of mud containing Republic-era ceramics, evidence that it was constructed before the Roman colonisation. Other, longer channels were about 20 m wide and ceramic fragments under the mud that covers them allow them to be dated later than the preceding work and, thus, refer to the Roman presence in the area.

Later, as is known, the entire lake bed was drained through the construction of an imposing subterranean tunnel<sup>1</sup>. This hydraulic work subsequently stopped working during the course of the 4th century AD and was heavily damaged by an earthquake in the 5th-6th century AD. This hydraulic work subsequently stopped working during the course of the 4th century AD and was healed with the consequent restoration of the lake's ancient surface area.

The effects of its lack of an outlet were soon felt by the settlements that, in the meantime, had increased in numbers and size, and the local population constantly asked for the works to be restored; some attempts were made but it was not until the mid-19th century that a new underground tunnel was built,<sup>1</sup> which partially incorporated the preceding one, providing a definitive solution to the problem and the consequent disappearance of the entire body of water.





**Fig.1** - The lowland of Fucino

<sup>1</sup> The work started in 41 a.d. when Claudio became emperor but was completed and fully functional only after the interventions of Adriano. The idea and the executive phases of the work project have been reconstructed by recovered data as documents and testimonies. From the beginning of the first phases of the research and after an appropriate survey of the characteristics of the land it was therefore evident that the drainage could be carried out by making the lake water flow in the Liri river, situated 20 m under the assumed average level of the bottom of the lake.

The shortest route would go under the Mount Salviano and cross the most southern area of the Palentini fields through heterogeneous lands made up of limestones, conglomerates and clays differing on lithological characteristics and consistency. In correspondence to the landmarks previously defined on the ground about forty square section wells were dug, by using a technique which is highlighted in the fragments probably belonging to the friezes which adorned the monumental part of the inlet. These wells reached a specific depth, from a minimum of 18 m to over 122 m, coincident with the rated plain at the end of the gallery. The excavation was directed from the bottom of the wells towards the opposite directions up to weld the various sections. At the entrance of the well a wooden armour dividing in four parts the section allowed both working squads a contemporarily and inverse movement of a couple of buckets.

The function of the wells was to facilitate the site ventilation where excavation and material transport took place; besides these wells, eight slanting galleries were created in the survey slopes, there where the height difference was too high to carry out.

The total length of the gallery was measured to be about 5.650 m, to these meters it is necessary to consider the addition of a deviation created between the wells n° 19 and n° 20 where at work ongoing it had been indispensable to get round a landslide caused by the contact among sandy clays and limestones. The route was not perfectly rectilinear, on the contrary it was characterized by small errors of deviation and variations of inclination.

The section of the gallery was rather variable, some segments were lined with bricks characterized by portions fixed with mortar other ones instead had no coating at all. A typical section had a surface of 5,05 m<sup>2</sup> for a course of 9,09 m<sup>3</sup>. The average inclination was 0,15% and a 8,44 m height difference was measured between the entrance of the inlet and the outlet to the Liri river.

The inlet itself was constituted of a trapezoidal basin followed by a roughly hexagonal shaped one with a 5,48 m level difference. On the outside in front of the basin there was a big collector 4,5 km wide with an inclination of 0,1%, a section of about 91,6 m<sup>2</sup> of which the first 300 metres were protected by wooden armours. Many lateral drain channels flowed into this collector.

This new gallery, commonly denominated "Torlonia Gallery", will be 6.301 m long with an average inclination of 0,1% and a 19.611 m<sup>2</sup> gallery section for a course of 50 m<sup>3</sup>/sec. The mouth of the outlet produces a total height difference of 7 m. 2.574 metres of the entire route were excavated into the limestone and were not provided with coating, 315 m were coated with bricks and 3.412 m were covered with tiles or armoured with masonry.



### ***The Social Background***

In 1875, after the completion of the last drainage phase, which saw about 1x10<sup>9</sup> m<sup>3</sup> of water poured into the adjacent Liri River in stages, the centre of the lake bed was now just a large marsh. The work proceeded by degrees and, in 1862, the first waters began to flow into the artificial canal while, at the same time, the land emerging from the water began to be reclaimed and organised with hydraulic works. When the works were completed, 210 km of roads, 100 km of canals and 648 km of drainage ditches had been constructed. In any case, as early as November 21, 1865, with drainage not yet finished, a government decree authorised Alessandro Torlonia, the only shareholder of the company that had obtained, first from the Bourbons and later from the House of Savoy, a concession for the total reclamation of the Fucino area, to take possession of all the land ....*that, upon the completion of the work, will remain dry due to the effect of the draining of the lake through the outlet....*and the Revenue Agency assigned the ownership of 14,005.90 hectares to the Torlonia family. In 1953, the Agrarian Reform led to the expropriation of all the Torlonia family's property and the vast landed estate was divided up into smaller parcels for a more direct and rational agricultural use. This necessary solution led to a radical transformation of the agrarian landscape and the settlement of the entire Fucino area and laid the foundation for its current prosperity, specifically, the opening of the A25 motorway, which provides fast transportation and, thus, better relations with the large markets.



**Fig.2** - The castle in Celano

### ***The Present Situation and the Cultural Exploitation of the Area***

The background provided is necessary for understanding the need, in many ways urgent, for decisive action to protect and promote the value of the area's landscapes. The European Landscape Convention, also known as the 2000 Florence Charter, lists its primary objectives as *"actions to conserve and maintain the significant or characteristic features of a landscape, justified by its heritage value derived from its natural configuration and/or from human activity"* and this is the framework for the project activities, partly realized and partly in progress, that are being considered here.

Firstly, the creation of a large Cultural Park is being proposed the key points to which are:

- 1) *the configuration of settlements.* This ambit includes the first settlements in natural caves, the creation of the "oppida" and "vici" circle (villages and estates) and the residential structures – scattered or gathered together – built following the Romanisation of the area, the medieval castles and the evolution of urban centres up to the radical reclamation of the 19th century. This event was to upset the entire natural economic and social landscape of the Fucino area and, as has been said, determined its current appearance;
- 2) *cultural and artistic tradition.* Over the centuries, the archaic drainage works and the presence of the lake, attracted the attention of the erudite and travellers of varied provenance and culture. As a consequence, there are noteworthy narratives and representations that provide evidence of a historic landscape that is only remembered through descriptions that are our sole source of information. Then, there is a literary heritage that includes many

works set in the Marsica region and in the Fucino area, in particular. In particular, Silone's work *Fontamara* is only one, important example of this tradition;

3) *the signs of the culture*. In other words, archaeology in its classic expressions consisting of artefacts, structures and material and industrial culture that, especially for the latter, are irreversibly degraded.

The *Fucino Cultural Park* intends to place all of these valuable aspects in a single container through the precise exploitation of these elements in thematic itineraries with the frequent possibility of intersections in order to offer a global overview of how an environment can be transformed into a territory.

In conclusion, as recalled on another occasion (Burri, 2002), the *Fucino Cultural Park* will, thus, perform a triple function:

a) preserving the memory of the works and techniques created to construct it;

b) preserving the memory of the many diverse communities whose origin was linked to the existence of the lake;

c) preserving the memory of the land and how it became the environment in which we live, constrained by the morphological dynamics that governed its past as they do its present.

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## HOLOCENE CLIMATIC-ENVIRONMENTAL CHANGES AND CULTURAL TRAJECTORIES IN MEDITERRANEAN AND NORTH-AFRICAN AREAS

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During the Holocene, intense changes in climate, in environment and in cultural systems have occurred <sup>(1,2)</sup>. Cultural trajectories have shown trends fairly coincident with climatic changes in Mediterranean and north-African areas <sup>(3)</sup>. In particular, three main dry events of key relevance for climatic-cultural changes seem to have occurred at ca. 8200 cal. yr BP, ca. 6000 cal. yr BP, and ca. 4200 cal. yr BP. Archaeobotanical records help to recognise and date human presence and activity in different territories <sup>(4)</sup>. Pollen and macroremains from archaeological sites strongly indicate that when human groups occupied a site or region, they exploited the territory and made a choice among plants for food, building and fire. They used and selected what the territory offered. When climatic/environmental changes occurred, humans changed their plant resources from time to time moving towards what was available on the territory and changing their subsistence strategies <sup>(5)</sup>. Overexploitation of thinned plant resources, including overgrazing, sometimes accelerated trend towards aridity during drying climatic phases. As humans enforced the aridity crisis, the relevant climate signal in palaeoclimatic records was enhanced. When dry climate depleted water and plant resources under a sustainable level, humans necessarily moved to new places. Anthropogenic indicators could be useful to distinguish climate signal from human impact in pollen records. Charcoals can be evidence of human activity in phases not deeply known by pollen data.

Examples of pollen and charcoal studies from these areas aim at presenting how impressive cultural changes had frequently concurred with critical climate oscillations. It seems that Bronze Age <sup>(6,7,8)</sup> had marked the environment more than the Neolithic, probably because there is a relation between knowledge improvement, culture development and evolution of complexity in land exploitation.

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## STRUCTURAL ANALYSIS OF THE ARCHAEOLOGICAL PATRIMONY OF THE “GRAN SASSO AND MOUNTAINS OF THE LAGA PARK”

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### 1. Introduction - Park description

The Gran Sasso and Laga Mountains National Park is considered as a natural European monument to the biodiversity because of the 2.600 different vegetal species around the 150.000 hectares and for the many animal species now dying out.

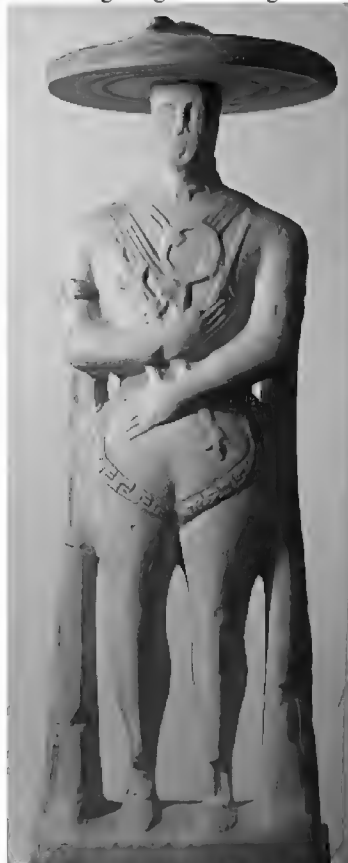
The park has been founded on 1991 and embraces 3 regions (Abruzzo, Lazio and Marche), 5 districts (Ascoli Piceno, L'Aquila, Pescara, Rieti and Teramo), 44 villages and 8 Mountain Communities.

Due to the wide area, the Park company divided the land into 11 environmental touristic-cultural districts making easy the relationships between local power, Regions and districts.

Many interesting archeological spots can be found just outside the park perimeter which have great importance for the whole naturalistic area. Numerous archeological and architectural witnesses are visible especially nearby the city of L'Aquila.

During the pre-Roman age the italic people living in the south and central-south of Italy, especially in the area where now the National Park is, were most of all the Sabins. The Capestrano's soldier, is one of the most impressive Italian artistic work and has been found in the old city of Aufinum (the present Ofena) in the south part of the park. The statue was found by accident on 1934 by a farmer of the area; it is totally made of chalky stone and represents a soldier dressed up with a beaver parade, sandals, the arms folded on the chest, a sword, a dagger a few other ornaments. The Capestrano's Soldier can be considered as the archeological symbol of the Park and of all the Abruzzo region.

Between the III and II century b.C. there was the first Roman expansion which brought to the conquest of the land and Ascoli was named as senator's province during Augustus' reign influencing the habit of the people.



**Fig. 1** - The Capestrano's soldier. Photo by Valentina Ferrari

The Amiternum town all represented the main urban pivot and during the highest pick of expansion, the population reached 10.000. When the Roman Empire collapsed, the land was first put under the Dukedom of Spoleto and then under the Reign of Sicily

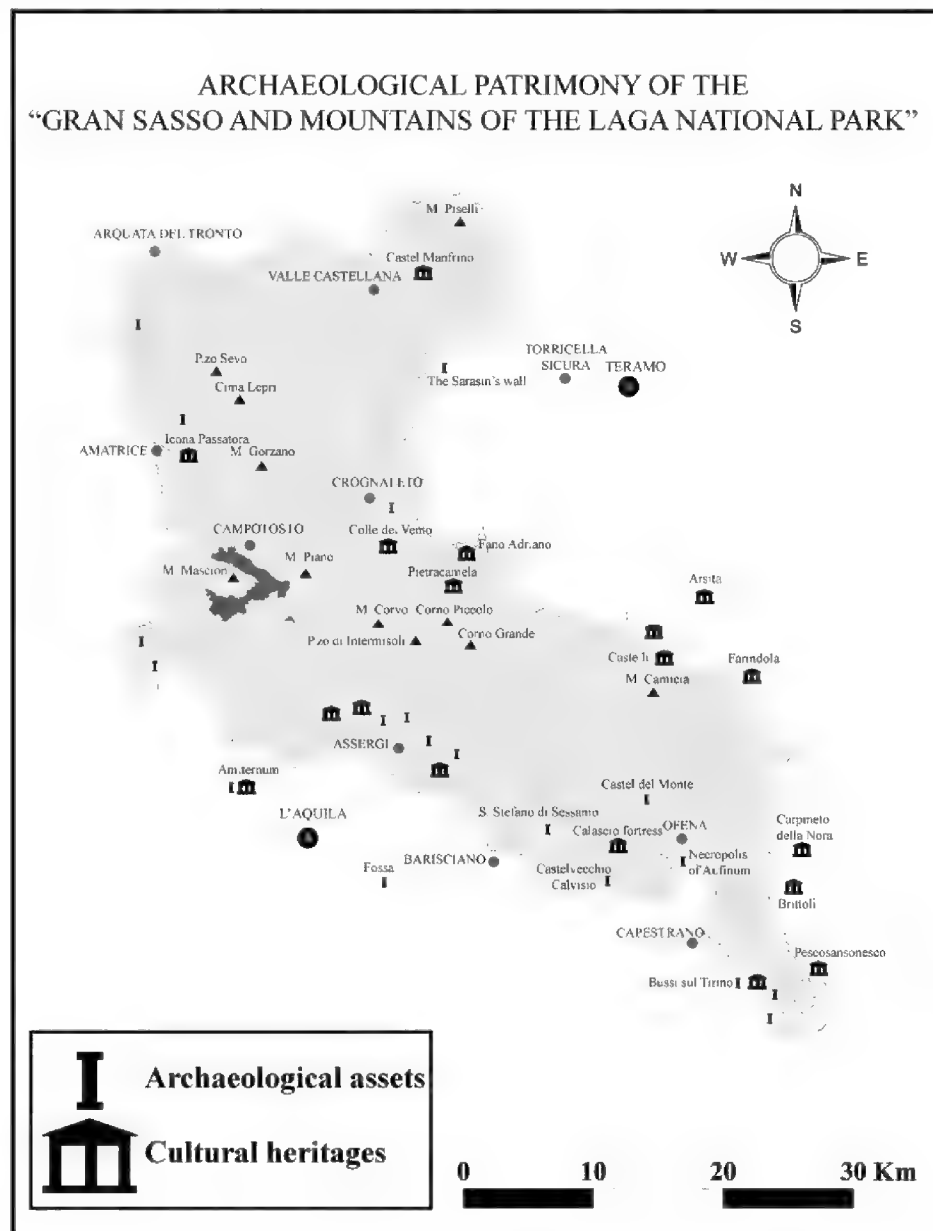


During the centuries and with the consequent administrative and cultural changes, the Park had the chance to gain a historical and cultural background rich of those elements which belong only to such territorial identity embedded since hundreds years until today.

## 2. Materials and methodologies

This work contains the space description of what the archeological, artistic, architectural and anthropological background is within the Gran Sasso and Laga Mountains Natinal Park and the nearby areas. This description has been done with the ArcView 3.2 software, a thematic map concerning the archeological and historical values of the Park employing also accurate symbolisms about the related elements.

Thanks to the regional territorial plans, the environmental and archeological bind map of the Abruzzo region and also with the employment of the topographic maps of IGM 1.25.0000 and the Plan of the Park, has been possible to find out which are the archeological binds and the cultural heritages inside the Park and all around it. According with the Plan of the Park, 68 are the archeological assets (including villages, single handiworks, necropolis, and shelters) and 188 elements recognized as cultural heritages (churches, sanctuaries, abbeys, cloisters, convents, monasteries, villas, castles, towers, religious constructions and so on).



**Fig. 2** – Structural analysis of the archaeological patrimony of the “Gran Sasso and Mountains of the Laga park”.

The research has been completed also thanks to the help given by many fieldwork investigations which made possible to really understand the real situation of the most important archeological spots especially considering what the earthquake on April 6<sup>th</sup> 2009 has done.



**Fig. 3** – Castelvechio Calvisio after the earthquake on April 6<sup>th</sup> 2009. Photo by Patrick Russo.

### **3. Amiternum**

More than 2000 years ago, a bunch of kilometers away from the city of L'Aquila, there was Amiternum, city established first by the Sabinis people and then, from 293 b. C., developed and improved by the ancient Romans, when the Sannit's wars had end.

The city arose on the Aterno river's banks on the Saint Vittorino's plane, few kilometers north from L'Aquila where many important Roman families used to live instead of the common people who lived in the Preturo's villas, on the hills around the plane. This was the mountain which originally hosted the main structure of Amiternum.

After the Roman conquest, the centre of Amiternum was moved into the wide plane and the city plan was regulated with a futuristic urban plan approach. From 1880 archeological probes have discovered an amphitheatre for 6000 people, a theatre of the Augustan age also used as necropolis, thermal baths and an aqueduct.

### **4. Calascio Fortress**

The fortress was built around 1000 a.D. and it is 1460 meters height and its intent was mainly military and for defense. Tirino and Navelli's planes could be controlled thanks to its strategic position. At the beginning the fortress belonged to the Piccolomini's family, the to the Medici's family which have widen the boarders to enlarge their business.

At the beginning the fortress only had one great tower and only with the Piccolomini's family the four cylindrical towers have been added giving to the fortress the aspect we can presently see.

Many times the fortress went under renovation works because of the damages provoked by numerous earthquakes which damaged the L'Aquila's area in the last centuries, especially the one on 1703 that totally destroyed the small village just under the fortress.



**Fig. 3** – Calascio Fortress. Photo by Patrick Russo

### **5. The megalithic walls of “Colle del Vento”**

Away from the touristic paths, on the Teramo's slope of the Laga mountains, there is the ancient “Colline del Vento” which represents the main monumental settlement in the north part of the National Park. Geographically the building is in the Crognaleto's area, precisely Piano Vomano at 929 meters from where was possible to control the Vomano river's valley at the border line with Teramo, L'Aquila and Sabina's territory.

The “Colline del Vento” hosted the “Paladins Walls”, two great megalithic walls of the Italic age where the biggest of them is 30mt long and 5mt height. The walls are made of huge blocks of polished green-sand blocks and were there to protect a village of 1.200 mq which is now only a small temple re-built with cubic rocks and with what remains of a middle age houses developed on artificial terraces.

The blocs of rock, of different sizes, are vertical and placed on 6 lines. Inside the small temple (8 meters per 4 meters) have been found a mosaic shaped floor and it could be an hypothesis that the temple was sacred because the worshipping of a San Martino of Campanea (nearby the Pieve) goddess. It seems that the temple has been built around the III century b.C. and his pick was between the II and I century b.C.

### **6. Magliano – The Sarasin's Walls**

On the north-west side of Torricella Sicura, the Magliano village, a small village with 35 inhabitants, hosts another example of fortress built up to protect a mountain path. At Magliano, there is the “Sarasin's Wall” which is a terrace concept sheering wall made of 6 sand stones blocks, today very well preserved, which are 15 meters long and 3 meters height. Still today their function foresees many theories. One of the theories historians consider is that, because the place where the wall is, it is possible to control the entire Vezzola valley and for reason the place is extremely strategic.

Another theory looks on that the ancient Romans, after had conquest and occupied the territory, would have built these terrace walls for an old sanctuary. Furthermore, during the Middle age this area was considered as the place where to build the church of S.Lorenzo of Magliano. The church is presently in ruins and the rests of it are preserved on a small hill where a local cemetery is. The first witnesses of this tiny church are of the XIV century. The last theory gives to the Saracens the responsibility to have destroyed the walls – and all the area - built up to keep the same Saracens away.

## SESSION A2 - REUSE OF HISTORICAL CENTERS

### HISTORIC TOWNS OF OUTSTANDING UNIVERSAL VALUE: EVALUATING THE APPROPRIATENESS OF NEW URBAN DEVELOPMENT TO ITS HISTORIC CONTEXT

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#### Abstract

Evaluating proposals for new urban development has long challenged the agencies concerned with the management of historic towns. Such developments can enrich the urban experience of historic towns, and can contribute towards their adaptation to contemporary life. Nevertheless, new developments suffering from poor townscape and architectural qualities might threaten the Outstanding Universal Value, OUV, of historic towns, and might detract from their authenticity and integrity. The main purpose of this study was to examine the influences of a group of factors on the appropriateness of the various approaches that might be adopted to introduce new development in historic towns. The study approached the issue by analyzing a selected sample of new developments introduced inside a group of historic towns. The historic town's townscape and historic values, and the new development's immediate surrounding environment were some of the examined factors. The examined approaches were classified according to the limit of tolerance associated with them. The findings revealed the outstanding influences of the new development's immediate surrounding environment. The immediate surrounding environments dominated by urban spaces seemed to tolerate the approaches associated with the utmost architectural individuality and freedom. The findings suggest that the evaluation of new development in historic towns should be based on the adopted Statements of Outstanding Universal Value, which should thoroughly address the various values contributing towards the property's OUV.

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**Keywords:** Urban conservation; development control; area-based conservation; historic towns; World Heritage Sites

#### 1.0. Introduction

Historic towns are considered as one of the most over-represented patterns of World Heritage Sites. The Egyptian properties inscribed on the World heritage List include one historic town, which is "Historic Cairo". Nevertheless, the Egyptian Tentative List includes another property representing historic towns, which is "Historic quarters and monuments of Rosetta/Rachid" [1].

The introduction of high quality new development inside historic towns might contribute towards their overall value, and might enrich the urban experience of these historic towns. The Washington Charter [2] recognizes the outstanding role that new development can play towards the harmonious adaptation of historic towns to contemporary life. Some examples of new development have contributed positively towards the overall value of historic towns in Egypt. The environmental enhancement in al-Hussein Square in "Historic Cairo" is an example of such positive new developments. In addition to the landscape elements in the square, the enhancement has also involved the installation of a group of high-tech sheds in front of al-Hussein Mosque to provide shaded areas for both prayers and pedestrians. Contrary to the previous instance, the new residential developments enjoying limited architectural value, which have overwhelmed Rosetta, seem to detract from the authentic spirit and feeling of the historic town.

The main aim of the paper was to examine the influences of a group of factors on the appropriateness of the various approaches that might be adopted to introduce new developments inside historic towns. To achieve the previous objective, a group of case studies of new developments introduced inside a selected group of historic towns were analyzed. Some of the analyzed new developments are located inside inscribed historic towns. These adopted historic towns included "Historic Cairo" in Egypt, "Historic Centre of Rome" in Italy, "City of Valletta" in Malta, "Hanseatic Town of Visby" in Sweden, and "Old and New Towns of Edinburgh" in The United Kingdom. Some other analyzed developments are located inside potential World Heritage Sites, which include "Historic quarters and monuments of Rosetta/Rachid" in Egypt, and "Mdina (Citta' Vecchia)" in Malta. The study previewed the results of the analyses and ended by concluding the influences of the examined factors.

#### 2.0. The Various Patterns of Historic Towns

Historic towns represent a subsidiary class of cultural heritage. The World Heritage Convention [3] classifies cultural heritage into three broad groups, which are "monuments"; "groups of buildings", which involve groups of



separate and connected buildings and historic towns; and "sites", which involve archaeological sites and cultural landscapes. The Operational Guidelines [4] further break down historic towns into other subsidiary categories, which are "towns which are no longer inhabited", "historic towns which are still inhabited", and "new towns of the twentieth century". "Mdina (Citta' Vecchia)", which is one of the properties listed on the Maltese Tentative List [5], seems to represent the "towns which are no longer inhabited". "Historic Cairo" in Egypt, and the "Old and New Towns of Edinburgh" in The United Kingdom, are examples of the "historic towns which are still inhabited". Finally, historic towns, such as "Brasilia" in the Brazil, can be considered an example of the third category of "new towns of the twentieth century".

The Operational Guidelines [6] classify the second category of "historic towns which are still inhabited" into four subcategories, which are "towns which are typical of a specific period or culture", "towns that have evolved along characteristic lines", "historic centers that cover exactly the same area as ancient towns and are now enclosed within modern cities", and "sectors, areas or isolated units". "Historic quarters and monuments of Rosetta/Rachid" seems to represent the subcategory of "towns which are typical of a specific period or culture" since most of the remaining Islamic Antiquities in the property belong to the Ottoman era.

### 3.0. The Various Patterns of New Development Expected to Take Place inside Historic Towns

New urban developments taking place inside historic towns might represent a variety of patterns. These patterns might involve the alteration of the original functions of historic buildings to other contemporary functions, or what can be called "change of use". The functions of historic buildings might be altered to museum function, such as the case of the Cathedral Museum in Mdina, which has originally been a baroque palace (Figure 1). Industrial heritage that failed to efficiently sustain its original function has also been reused into other functions such as heritage centres.

Constructing new architectural elements concealed behind the retained façades of the historic buildings is another pattern of new development that can be called "building behind retained façade". The patterns of new development also include the horizontal extensions to existing historic buildings, which can be called the "extension" pattern. The Museum of Scotland, in the Old and New Towns of Edinburgh, which is an extension to the Royal Museum, is an example of this pattern (Figure 2). Constructing completely new buildings represents another pattern of new development that can be called "new constructions". Gotland University, in the Hanseatic Town of Visby, is an example of this pattern (Figure 3). The last pattern of new development is the environmental enhancement of urban spaces. The pedestrianization of the Republic Street and the Great Siege Square, in the City of Valletta, is an example of this pattern (Figure 4).



**Figure 1.** The Cathedral Museum in Mdina (Citta' Vecchia) potential World Heritage Site



**Figure 2.** The Museum of Scotland in the Old and New Towns of Edinburgh



**Figure 3.** The library building in Gotland University in the Hanseatic Town of Visby



**Figure 4.** The Republic Street and the Great Siege Square in the City of Valletta

### 4.0. The Various Approaches to Introduce New Development inside Historic Towns

New urban development can be introduced through various approaches. These approaches were classified into three major groups. The first approach, which was called the "utmost disclosure approach", involves two subsidiary contradicting approaches. The first is the "copy approach", which has also been called the "contextual uniformity"

approach [7]. The "copy approach" allows architects to adopt the historic towns' prevalent architectural styles. The Scandic Crown Hotel, in the Old and New Towns of Edinburgh, is an example of this subsidiary approach (Figure 5). This approach has been rigorously criticized because it might lead to the introduction of superficial imitations of historic features, which are usually referred to as "pastiche" [8].

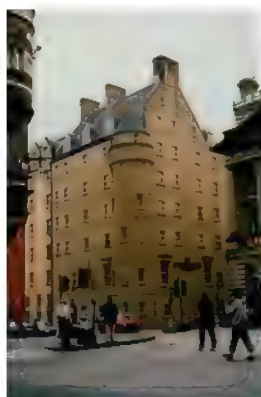
The other subsidiary approach of the "utmost disclosure approach" was called the "contrast approach". This approach is concerned with adopting an intrusive architectural style totally contradicting with the prevalent ambiance in the historic town. This approach, which has also been called "contextual juxtaposition" [9], is closely associated with the "Modernism" movement in architecture [10]. The Dynamic Earth in Edinburgh is an example of this approach (Figure 6). This approach has been criticized because it creates substantial gaps with the history of the surrounding area, and because of the visual monotony and the shallow façades resulting from the standardization of the architectural elements associated with this approach [11].

The second approach was called the "style allusion approach". Through this approach, new developments are designed to allude either the prevalent architectural style, or another intrusive style. This approach involves two subsidiary approaches, the first of which depends on the Post-Modernism architectural principles. Through this subsidiary approach, which is also called "contextual continuity" [12], new development is related to its context by adopting the Post-Modernism style [13].

The second subsidiary approach of the "style allusion approach" was called "using link". Through this subsidiary approach, the visual relationship between the new development and its historic context is established by using a tangible link. These links might include using mutual colors, materials and textures. Conformity to the prevalent buildings height might be another link [14]. The extension to the Roxburghe Hotel in Edinburgh is an example of this approach (Figure 7). Sandstone has been used as a mutual material linking the old building with its extension. The conformity of the height of the extension to the height of the original building is also another linking feature.

The third approach was called the "neutral approach". The neutral approach allows the introduction of new development that neither alludes glimpses of prevalent or intrusive styles, nor does it boldly echo its surrounding nor sharply contrast with it. The neutral approach can be achieved by completely hiding the new development behind the retained façades of the historic building. The Savoy shopping mall in Valletta is an example of this approach (Figure 8).

The neutral approach involves another subsidiary approach that can be called "using screen". New developments representing this subsidiary approach usually face their surrounding historic context through a reflecting glass screen that is meant to mirror the historic buildings instead of imposing any intrusive architectural styles. This approach has been associated with the "Minimalism" architectural style. The Tun in Edinburgh is an example of this approach (Figure 9).



**Figure 5.** The Scandic Crown Hotel in the Old and New Towns of Edinburgh



**Figure 7.** The extension to the Roxburghe Hotel in Edinburgh



**Figure 8.** The Savoy shopping mall in the City of Valletta



**Figure 9.** The Tun in Edinburgh



**Figure 6.** The Dynamic Earth in Edinburgh



## **5.0. The Various Factors that Influence the Appropriateness of the Adopted Approaches to Introduce New Development**

### **5.1. The townscape value of the historic town**

Selecting the appropriate approach by which new development can be introduced inside historic towns is influenced by a group of factors. The first influencing factor is the townscape value of the historic town. The townscape value of historic towns might be expressed by the harmony of their urban contexts and the ability to subdivide them into subsidiary identity areas. The more harmonious the character of historic towns, and the less possible it is to subdivide them into identity areas, the less possible it is to introduce sharply contrasting new developments inside them.

Historic towns can be subdivided into identity areas based on a group of criteria, such as the historic value of the various zones in the historic town. The Old Town Conservation Area, CA, in Edinburgh is an example that illustrates the influences of the ability to subdivide historic towns into identity areas on the appropriateness of the adopted approaches to introduce new development. Based on the historic value of its urban fabrics, the CA can be subdivided into two identity areas. One of these identity areas, which covers the Waverly area, is characterized by its relatively new urban fabrics, in comparison with the much older other identity area covering the rest of the CA.

The CA can also be subdivided into five identity areas based on the dominance of either built up areas or urban spaces. Only one identity area, which stretches along the Royal Mile and to the south of the CA, is dominated by built up areas, while the others are dominated by urban spaces. The CA can be subdivided into two identity areas based on the dominant architectural styles. One of these identity areas, which is the area enclosed by the Canongate Street and the Holyrood Road, is dominated by modern architectural styles, while the other is dominated by either Georgian or Victorian architectural styles. Based on the building height of its urban fabrics, the CA can also be subdivided into two identity areas. One of these identity areas, which is the area stretching along the Royal Mile, is dominated by high buildings, while the other is dominated by low buildings.

The many criteria by which the CA can be subdivided into identity areas indicate the considerable decline of the harmony of its character. Therefore, it seems that it has been possible to introduce a group of new developments that sharply contrast with their historic context. The Dynamic Earth (Figure 6) and the Scottish Parliament are examples of these developments. Contrary to Edinburgh, Mdina in Malta seems to enjoy a harmonious townscape largely because of its compact layout. Consequently, the urban fabrics of Mdina can not be subdivided into identity areas. The harmonious townscape of Mdina seems to have limited the chance to introduce sharply contrasting developments in the property. Most of these new developments have been limited to patterns such as change of use. The adaptive reuse of a baroque palace, previously used as a seminary, into a museum, which is the Cathedral Museum, is an example of such developments [15] (Figure 1).

### **5.2. The immediate surrounding environment**

The second factor is the influence of the urban environment immediately surrounding the new development. New development's immediate surrounding might be dominated by either built up areas or urban spaces. The introduction of sharply contrasting new developments seems to be more possible when the new development's immediate surrounding is dominated by urban spaces. The Scandic Crown Hotel in Edinburgh is an example of the new developments that illustrates the influences of this factor (Figure 5). Influenced by the characteristics of its immediate surrounding, which is dominated by built up areas, the design of the hotel largely mimics the architectural features of its surrounding.

Contrary to the previous example, the environment immediately surrounding Gotland University, in the Hanseatic Town of Visby, is dominated by urban spaces. The modern university's buildings are surrounded, from one side by the Almedalen Garden, and from the other side by the harbor. Consequently, instead of copying its historic context the library has been designed to reflect its surrounding through a glass screen, and has responded merely to the surrounding prevalent building height (Figure 3).

New developments' immediate surrounding might be dominated by Listed Buildings or Scheduled Monuments. The larger the number of Listed Buildings or Scheduled Monuments in the development's immediate surrounding, the more likely it is to adopt the design approaches that copy the surrounding historic context. The urban environment immediately surrounding Charlotte Square in Edinburgh is dominated by a large number of Listed Buildings. Consequently, the design of the new office development overlooking the square tends to copy the architectural style of its surrounding context (Figure 10). Contrary to Charlotte Square, very few Scheduled Antiquities have survived in the area surrounding the Horriyah Square in Rosetta, such as Arab Killi House. As a result, the Rosetta International Hotel and other residential developments seem to have been designed as modern landmarks sharply contrasting with the historic spirit of the area (Figure 11).

New developments' immediate surrounding might also be dominated by either modern or harmonious historic architectural styles. The introduction of sharply contrasting new developments seems to be more possible when their immediate surroundings are dominated by modern architectural styles. The Canongate Major Development Opportunity Area in Edinburgh is an example of such local environments dominated by modern architectural styles. The design of the new developments inside the area, such as the Macdonald Hotel and the Scottish Parliament, or overlooking it, such as the Dynamic Earth (Figure 6), seems to have disregarded the characteristics of the historic contexts in the property. On the other hand, the Canongate Street is dominated by a harmonious historic architectural style. Therefore, the design of new developments in the area, such as the 112 Canongate, designed by Richard Murphy, has tried to make reference to the distinctive architectural features in the area [16] (Figure 12).



**Figure 10.** 3 Glenfinlas Office Development in Edinburgh



**Figure 11.** The Rosetta International Hotel



**Figure 12.** The 112 Canongate in Edinburgh

### 5.3. The pattern of the historic town

The third factor is the pattern of the historic town. Inhabited historic towns, such as Historic Cairo, undergo enormous pressures for residential developments. To meet such pressures, it is more likely to consider the visual impacts of the surrounding historic contexts of inferior significance; therefore such influences are usually disregarded. On the other hand, historic towns that are no longer inhabited, such as Mdina, usually undergo pressures for commercial and cultural developments merely. Because such pressures do not necessitate radical changes, it is more likely to adopt patterns of new development, such as change of use, and approaches of design that respect the coherent character of these historic towns.

### 5.4. The pattern of the proposed new development

The fourth influencing factor is the pattern of the proposed new development. The patterns of development that are totally concealed from the public urban spaces, such as change of use or building behind retained façade, are more likely to disregard the character of the surrounding historic context. The Savoy shopping mall in Valletta is an example of such developments (Figure 8). On the other hand, the patterns of new development that visually encounter their surrounding historic context, such as new constructions, are expected to respond to the prevalent historic character. The office development overlooking Charlotte Square in Edinburgh is an example of such developments (Figure 10).

### 5.5. The extent of the historic town

The extent of the historic town is also another influencing factor. The larger the area of the historic town, the more likely it is to subdivide it into identity areas, and subsequently the more possible it is to introduce contrasting new developments. Inside such vast historic towns, it seems more likely to adopt approaches to introduce new development, such as the "contrast" or the "neutral" approaches. The Old and New Towns of Edinburgh, whose extent reaches about four and a half square kilometers [17], is an example of such historic towns. On the other hand, compact historic towns whose extent is very limited are less likely to be subdivided into identity areas. Therefore, new developments introduced inside these historic towns are expected to respond to the character of the property. Mdina, whose total area is about 0.04 km<sup>2</sup> [18], is an example of such historic towns.

### 5.6. The historic value of the historic town

The historic value of historic towns is another influencing factor [19, 20]. The age of the historic fabrics was adopted as an indicator of the historic value of the historic town. Historic towns whose urban fabrics are very old are more likely to tolerate patterns of development, such as change of use, and approaches to introduce new development that copy the surrounding environment. The Historic Centre of Rome is an example of such historic towns. The historic value of the property, indicated by its Roman origins, must have limited the possibility to introduce contrasting modern developments. Historic towns, whose historic fabrics are relatively modern, such as the New Town in Edinburgh, are more likely to tolerate sharply contrasting new developments. The plethora of modern commercial developments along Princess Street and modern office buildings in the New Town emphasizes such influences (Figure 13).



**Figure 13.** Modern developments in the New Town in Edinburgh

### 5.7. The statutory protection status

The statutory protection status granted to historic buildings, which will be the subject of developments such as change of use or extensions, is another influencing factor. These statuses might involve the Listed Building or the Scheduled Monument status. In Malta, the grade of the Listed Building usually influences the evaluation of applications for new developments, such as the demolition of Listed Buildings [21]. Adopting the approaches that allow the introduction of sharply contrasting new development seems to be unlikely when the concerned historic building is granted a statutory protection status.

The Museum of Scotland is an example of such developments affecting Listed Buildings. The museum has been an extension to the Royal Museum, which is an A Listed Building [22] (Figure 2). Avoiding the sharp contrast with the historic context, the Museum of Scotland has been visually linked to the Royal Museum by using a mutual finishing material of façades, which is sandstone. Contrary to the previous example, the Tun in Edinburgh has been an extension to an unlisted brewery. The extension has been designed to reflect its surrounding through a glass screen (Figure 9). Such a design approach reflects a limited response to the characteristics of the surrounding historic context, in comparison with other approaches such as the link or the copy approaches.

### 5.8. The Statement of Outstanding Universal Value and the other relevant official documents

The last factor is the Statement of Outstanding Universal Value and the other official relevant documents. The Operational Guidelines [23] indicate that the Statement of Outstanding Universal Value should be the key reference for the management of inscribed properties, including the control of new development. These statements are brief documents concerned with the justification of the inscription of historic towns on the World Heritage List.

Instead of the Statement of Outstanding Universal Value, a Statement of Significance has been adopted for the Old and New Towns of Edinburgh. The statement briefly addresses the significant values of the property, such as the townscape and the architectural values, and lists examples of some of the elements contributing towards these values [24]. The analysis of the values of the property is further detailed in the management plan [25].

Conservation Areas' character statements and appraisals are other influencing official documents. The previous examples of new development in the property have been evaluated against the then adopted character statements. The seven Conservation Areas covering the entire World Heritage Site have been designated using a character statement; later on the character appraisals of these CAs have been prepared. The Old and New Towns CAs have been designated in 1977 depending on character statements, later, their character appraisals have been approved in 2005 [26, 27]. Since the World Heritage status can not establish further statutory controls in the United Kingdom [28], the efficient control of the quality of new developments in the property seems to have been more influenced by the local protection measures and the local official value analyses.

### 6.0. Conclusions

The previous preview seems to indicate that the evaluation of the appropriateness of the various approaches to introduce new development should be based on a detailed analysis of the values of the historic town, particularly those contributing towards its OUV. These values might include historic, newness, architectural and townscape values. Other factors seem to also influence the evaluation of the adaptability of new development to its historic context, such as the statutory protection status granted to historic buildings and the pattern of the new development. The findings seem to indicate that some factors, such as the new development's immediate surrounding, enjoy an outstanding influence, while others, such as the pattern and extent of the historic town and the statutory protection status, enjoy less influence.

The findings seem to indicate that the objective of controlling new development inside historic towns should be to preserve or enhance the values that contribute towards their OUV. The findings seem to suggest the need to develop detailed Statements of Outstanding Universal Value that address all the values contributing towards the historic towns' OUV, and that also list the various elements conveying these values. These statements, along with any other official documents concerned with value analyses, should be a key reference while evaluating applications for new development inside historic towns.



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# THE LIGHTHOUSES OF ALEXANDRIA “LET THERE BE LIGHT”

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**Keywords:** Maritime Heritage - Lighthouses - Conservation - Alexandria

*‘Where there is light, there is life’*, Henry Plummer

## 1. Introduction:

Alexandria is one of the oldest cities in the Mediterranean. The city had a crucial role in shaping the history of the Mediterranean. Alexandria is also famous for its legendary lighthouse, the Pharos, one of the seven wonders of the ancient world. The lighthouse stood on the small Pharos Island for almost 13 centuries. Even though the Pharos collapsed its legend and fame still survives. Pharology, which is the science of designing lighthouses, is named after the Pharos. The great lighthouse of Alexandria caught the attention of travelers, historians and the like. Even today its reputation and fame overshadow *the other* lighthouses of Alexandria. This paper aims to study *the other* lighthouses, the ones that are lesser known but have marked the coast of the city for more than a hundred years. This research will trace the history and architecture of the lighthouses of Alexandria, their role in shaping the city’s waterfront, their characteristics and their lighting technology.

## 2. Why Study Lighthouses?

- The fame and legacy of the great Pharos of Alexandria has put other lighthouses of the city in the shade.
- The last study about the lighthouses of Alexandria was conducted in 1912 by Gaston Jondet and B. Malaval. Since then there has been no record or research of these unique structures.
- The lighthouses are an endangered type of buildings and soon will be obsolete because of the new navigation technology.
- Lighthouses are always located in areas with the harshest type of weather condition making them more liable to deterioration and degradation.

## 3. The aim of this research:

- 1 To document the lighthouses of Alexandria
- 2 To study their existing condition
- 3 To highlight their importance as part of maritime heritage
- 4 To raise awareness of their need of conservation

## 4. The history of lighthouse construction

During the 1800s, lighthouses were part of the general public works plan carried out by Mohamed Ali the Viceroy of Egypt, in his goal to modernize Egypt, and to make it a competitor to European countries. To achieve this goal, railways, canals, bridges, telegraph posts, arsenals, docks, irrigation canals and harbors were constructed all over Egypt. Several lighthouses were constructed along the coast of Alexandria and eastwards in Rosetta, Damietta, Cape Bourlos and Port Said to facilitate the navigation of trade and navy vessels to and from Egyptian ports.

Mohamed Mazhar Pasha studied engineering and mathematics for 10 years in France during the 1830s. He was the chief engineer during the reign of Mohamed Ali [Tousson 1934]. Among his engineering and military tasks, he was responsible for the construction of the first modern lighthouse in Alexandria at the tip of Ras El Tin Peninsula (El Rafei 2001). This lighthouse was constructed while Mohamed Ali concentrated on the renovation of the Alexandria seaport and his wish to establish a powerful, well-equipped navy.

Later many lighthouses were constructed due to the energy and intelligence of Mickillop or M. Killop Pasha [Jondet 1869]. Mickillop Pasha was a British Royal Navy soldier and the Headmaster of the Egyptian Navy School. He was appointed as the first chief of the Lighthouses Department which was established in 1868 [El Mesieri 2007]. The location of each lighthouse was carefully chosen by a specialized committee that comprised of experienced Egyptian sailors and professional maritime engineers under the supervision of experienced foreign experts. [El Mesieri 2007] At the death of Said Pasha, in 1863, the lighthouse which is located in Ras El Tin was the only structure of its kind in any Egyptian port along the Mediterranean. Ismail Pasha (ruled 1863 - 1879) was responsible for the construction of several lighthouses in Alexandria such as the ones in Agami (1873), the lighthouse at the end of the breakwater erected in the Alexandria port (1876), and Qabbari lighthouse (1877).

## 4. Existing lighthouses of Alexandria

There are six lighthouses still existing in Alexandria. They are mainly located in the western part of the city except for Montazah lighthouse which is located in the Montazah Palace grounds to the east of the city. Some of these

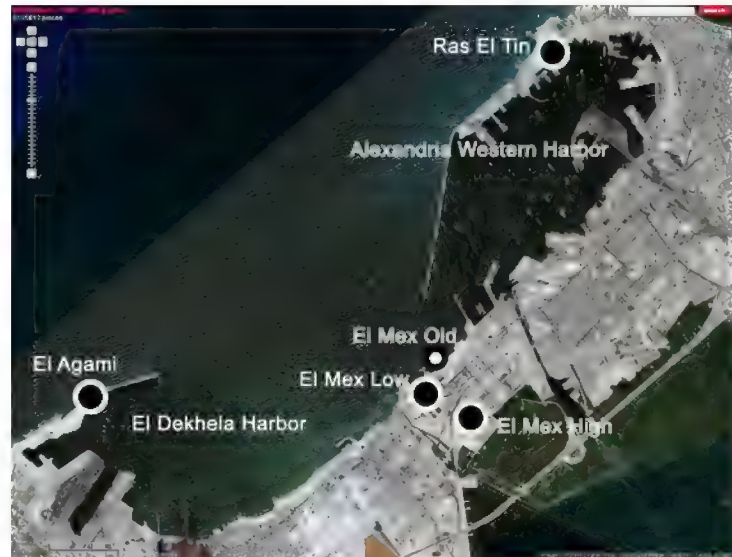
lighthouses are not functional and others are not accessible. Figure 1 shows contemporary Alexandria with the location of existing lighthouses in the western part of the city. Table I exhibits some characteristics of the existing lighthouses of Alexandria.

**Table 1:** A list of existing lighthouses of Alexandria

	Lighthouse name	Other names	Date of Construction	Location	Height	Range	Functional	Description	Type
		(if any)			(m)	(nm)			
1	Ras El Tin	-Old lighthouse, -Alexandria lighthouse - Grand Phare	18482	Ras El tin peninsula	552	211	yes	White round stone tower, black bands <sup>1</sup>	manned
2	Mex Low	El Boughaz El Kebir	19082	El Mex	202		yes	Tapered with vertical red and white stripes	manned
3	Mex High	El Mex	18942	El Mex	302		yes		manned
4	Mex Old	El Fanara EL Amya (Blind lighthouse)	1890-1891 <sup>5</sup>	El Mex			no		unused
5	El Agami <sup>1</sup>	none	18733	Marabout Island	171 314	151	yes	White stone tower, vertical black stripes <sup>1</sup>	unmanned
6	Montazah Palace	none	1940s	Montazah Palace	152		yes		unmanned

Source: <sup>1</sup> [www.beacon-egypt.com/lights](http://www.beacon-egypt.com/lights), <sup>2</sup> <http://www.unc.edu/~rowlett/lighthouse/egy.htm>, <sup>3</sup> El Rafei, (1987), Asr Ismail, Dar El Maa'ref, Part 1, 4th Edition. (Text in Arabic), <sup>4</sup> Egyptian Authority for Maritime Safety

**Figure 1:** Satellite image of contemporary Alexandria illustrating the functioning lighthouses in black and the non functioning lighthouses in white  
source: the author, base map after Google earth



#### 4.1 Ras El Tin Lighthouse

Also known as the Grand Phare. Ras El Tin lighthouse was constructed in 1842 [Shafei 1950], during the reign of Mohamed Ali, by Mohamed Mazhar Pasha, and was operational in 1848 [Malaval and al. 1912]. The lighthouse was modified several times starting in 1919, provided with electricity in 1954, and lastly was renovated in 1993 [Rowlett 2007]. Being located at the tip of Ras El Tin Peninsula, the lighthouse acts as a regional or landfall light and marks the entrance to the Western Harbor of Alexandria. It is the first landmark seen on approaching Alexandria along with the Marabout Fort to the west of Agami. [Malaval and al. 1912]

The lighthouse consists of a circular tapered wall-bearing stone tower with an outer diameter of 9.30m and wall thickness of around 1.20m. The stones were brought from the quarries of Cairo. The height of the building is 49m while its focal plane is 55m above sea level. The tower has a lantern and gallery. Its light characteristics are three white flashes, in a 2+1 pattern, every 30 seconds. The lighthouse was surrounded by a fort which was called El Fanar Fort or Ras El Tin Fort. Most probably, this fort was destroyed during the British bombardment of Alexandria in 1882.

Early photos of the lighthouse indicate that it was built with exposed stones which, most probably during the renovation of 1919, were plastered and painted in horizontal black and white stripes [Ilbert and al. 1997]. The lighting equipment of the lighthouse consisted of a lantern with 24 panes. The mechanism was replaced and provided by Sauter of Paris in 1905 [Malaval and al. 1912]. Originally the lighthouse used not to have a light source as indicated by Sir John Gardner Wilkinson (1797-1875) who in 1847 described the lighthouse as being in a good



position for vessels arriving from Europe but, he continues, that he [Mohamed Ali] made a mistake of not having a revolving light, which might have been done with little more expense [Wilkinson 1847]. Figure 2.



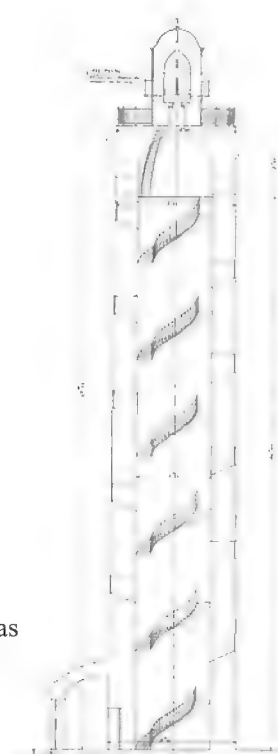
**Figure 2:** Southern view of Ras El Tin Lighthouse  
*source: The Alexandria & Mediterranean Research Center*

The lighthouse is located within the headquarters of Egyptian Navy as well as the presidential Palace of Ras El Tin, which are restricted areas accessed only with a special permission. It is equipped with a light station that consists of a generator for electricity back up, living quarters for workers, a small workshop and an office. Figure 3. The top of the lighthouse can be reached by a spiral, cantilevered stair that connects the ground floor to a level just below the lantern room. Then a small one flight stair leads to the lantern room. In around 2000 an elevator was installed. The light source is a light bulb with a revolving lens. Even during the day, the lens revolves so as not to concentrate the sun rays into the lantern. Figure 4. The lantern is equipped with an external and an internal gallery for the maintenance of the lens. The condition of the building is fairly good except for few external cracks in the plastering. Windows are broken due to the harsh weather with birds cages inside the tower.

**Figure 4:** Plan of the Ras El Tin Lighthouse  
*source: Egyptian Authority for Maritime Safety*



**Figure 3:** Section of Ras El Tin Lighthouse.  
*source: Malaval and al.*

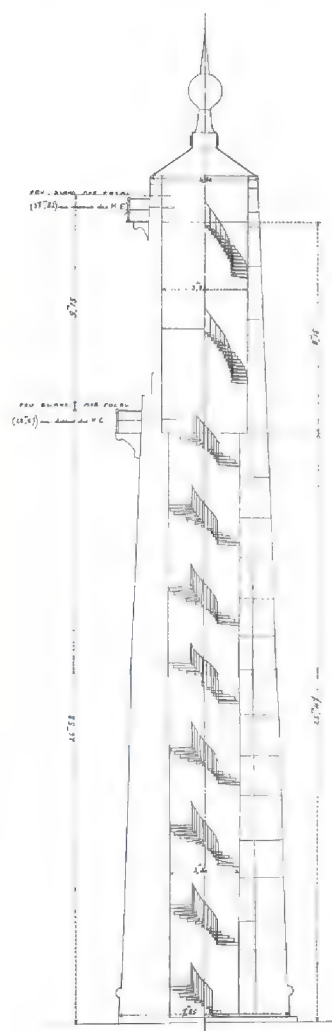




#### 4.2. Mex High Lighthouse

Also known as Mex Grand Lighthouse. Constructed between 1890 - 1891 and lighted in 1894, the same year of the construction of the Mex Old Lighthouse which was erected on an island about 150 meters from the coast. The construction of both lighthouses cost about 3600 EGP. The original light source was provided by Lux and was visible from a distance of 10 miles [Malaval and al. 1912]. The light has a focal plane of 38m. Its light characteristics are two continuous white lights, one above the other; the lower is at a focal plane of 29m. The total height of the lighthouse is approximately 30m. [Rowlett 2007]. The building is a round tower with double gallery and a dome topped by a ball-and-spike day mark. The upper half of tower is painted black, the lower half white. The light is located within a light station which is rectangular with a central open court. The condition of the lighthouse is fairly good with some longitudinal cracks in the external plastering. The Mex High Lighthouse works with the Mex Low Lighthouse to indicate a safe passage for vessels entering the harbor. Figures 5, 6.

**Figure 5:** Northern view of the Mex High Lighthouse, source: the author source: Malaval and al.



#### 4.3. Mex Low Lighthouse

Mex Low Lighthouse was constructed in 1908 while the station was established 1894. The lighthouse is still active; with a focal plane of 18m, it has two continuous red lights, one above the other; also a continuous white light at a focal plane of 13 m. Its total height is 20 m. It is a round tapered tower with a domed top rather than a lantern; the lights are shown through small openings. The tower is painted with vertical red and white stripes. The lighthouse is manned with an adjacent light station that houses services. The lighthouse consists of an external stair to reach the summit while maintenance is undertaken by using an internal staircase [Rowlett 2007]. The top of the lighthouse is marked with an ending decorative spike. Some professional mariners, such as Peter Mosselberger, describe the Mex Lighthouses as the most beautiful leading lights in the world. Figure 7.



**Figure 7:** RIGHT The signal tower of Mex, to the far left and the little lighthouse of Mex to the right in 1897. LEFT The signal tower was deserted and the little lighthouse was renovated to what is now the Mex Low Lighthouse  
source: [www.egyptedantan.com](http://www.egyptedantan.com) and Malaval and al.



**Figure 8:** Views of the Low Mex Lighthouses showing their setting and alignment  
source: *The Alexandria & Mediterranean Research Center*

Old photographs taken around 1897 show that the Mex Low Lighthouse was originally a signal tower before it was converted into the current Mex Low Lighthouse. The same pictures illustrate that the Mex Old Lighthouse – which is now deserted – was a functioning lighthouse at that time. It is not known so far the reason for neglecting of the Mex Old Lighthouse and renovating the Mex signal tower to be a lighthouse. Figure 8.

#### 4.4 . El Agami

An unmanned lighthouse. The construction date of this lighthouse is unknown but some references state that it was constructed in 1873 [El Rafei 1987]. It has a height of 14m and a focal plane of 17m, with two white flashes every 15 seconds. It is a stone tower with a lantern and gallery, painted with vertical black and white stripes. The lighthouse is located on a spit at the westernmost entrance to the harbor area, about 20 km southwest of the center of Alexandria. The Agami lighthouse is located in a restricted no access military area controlled by the Egyptian Coast Guard Forces. As a result little is known about the condition of the light. Figure 9. It is not known to the author if the existing lighthouse is the original building that was constructed in 1873 or if it has been renovated or even reconstructed.



**Figure 9:** The Agami unmanned lighthouse/or beacon  
*source: Egyptian Authority for Maritime Safety*

## 5. Other notable “dark” houses

### 5.1. Montazah Palace

This lighthouse is located on the King's Tea Island in front of the Salamlek Palace at the eastern end of Alexandria, within the boundaries of the royal palace of Montazah. The construction date is around 1940s, after the construction of the Tea Island Bridge in 1941. The light is inactive. Its height is about 15m and it is constructed out of stone, unpainted plaster, with vertical fluting, a lantern, and gallery. It does not appear that this lighthouse was ever an official aid to navigation, although decorative lights may have been displayed. Many Egyptian romantic films were shot underneath the feet of the Montazah lighthouse. Figure10.



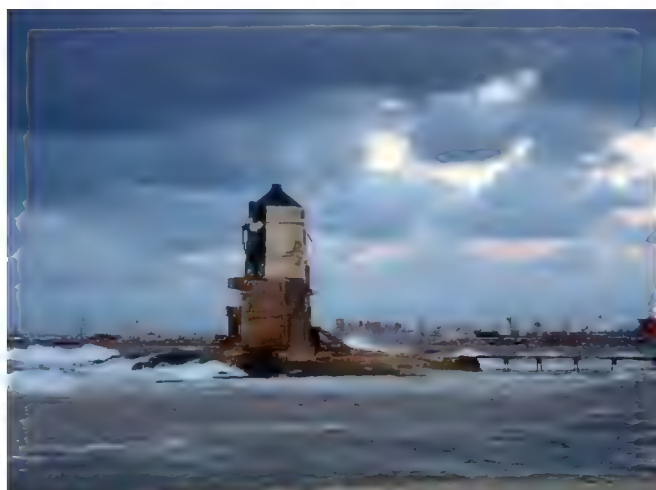
**Figure 10:** The Montazah Lighthouse  
*source: The Alexandria & Mediterranean Research Center*

### 5.2. Mex Old Lighthouse

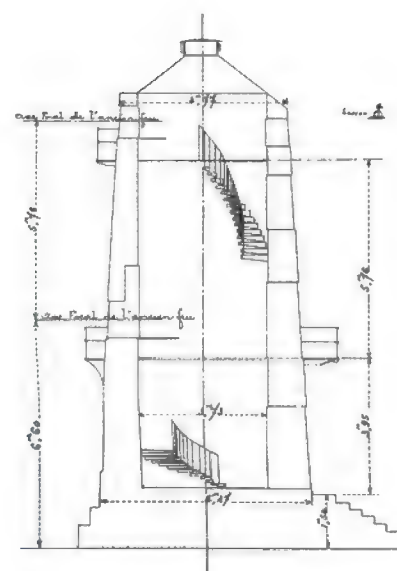
It was on January 1<sup>st</sup> 1908 when the light of the Mex Old Lighthouse was switched off. [Malval and al. 1912]. The reason for this is most probably the building of a newer and higher lighthouse, the Mex Low Lighthouse. Now the Mex Old Lighthouse stands deserted and unmaintained facing the strong waves and harsh weather. The wooden bridge that once connected the lighthouse to the mainland is broken. Built in white sandstone with two galleries and without a lantern, the light was named in old photographs as signal tower not as a lighthouse. It is worth noting that the area around the lighthouse was named the Old Lighthouse Bay as it appeared in some maps. The lighthouse is named among locals as the “blind lighthouse” because it is dark and not functioning. The lighthouse used to be a signal tower in the early 1920s. It has two galleries and a beacon with vertical white and black stripes.

An adjacent structure built in reinforced concrete near the lighthouse seems to be of a more recent period, most probably as a place for its keepers. The light was an unmanned light signal. Sometimes it was mentioned in old paragraphs as a semaphore however in some maps it was named a lighthouse or the “little tower of Mex” (petite tour de Mex), as in the map of 1917 by the Survey Department of Egypt. Figures 11, 12.





**Figure 11:** The deteriorated condition of Mex Old Lighthouse, Lighthouse, *source: Alexandria & Mediterranean Research Center*



**Figure 12.** Section of the Mex Old Lighthouse *source: Malaval et al.*

## 6. Vanished Lighthouses

Aside of these functioning and nonfunctioning lighthouses, there used to be other lighthouses that have now vanished. Examples of these lighthouses include:

### 6.1. El Qamareya Lighthouse

It was constructed in 1909 [El Sharkawy 2001]. It was located in the area of Qabari. It is not assured if it was a lighthouse or a signal tower because some maps name it as a signal tower for vessels. It is deduced that this lighthouse might have been dismantled to give way to new constructions and improvements of the harbor of Alexandria.

### 6.2. The Qabbari Lighthouse

This lighthouse was built in 1877 and is mentioned in some references as being built by Ismail Pasha [El Rafei 1987]. However it is not shown in maps of Alexandria.

### 6.3 El Omayed Lighthouse

This lighthouse is located in El Omayed, about 80 km west of Alexandria. It was constructed near a castle built in the 13<sup>th</sup> century by Sultan Bybars. In 1873 a lighthouse was constructed close to the castle. It is believed that the castle was knocked down to provide required stone to build the light-keeper's quarters. However Robecchi-Bricchetti who visited the place in 1885 alleges that the castle was still standing. The lighthouse was erected by Ismail Pasha to please a foreign power which had had a ship wrecked along the coast of the Mediterranean. The light was extinguished during the First World War and had never been lit since. [De Casson 1935]

### 6.4 Tour de la Mission d'Egypte

The tour de la Mission d'Egypte was located at the North Eastern part of Ras El Tin Peninsula. As Gaston Jondet indicated, it was constructed by the French army at the time of the French Expedition to Egypt in 1798. It was a cylindrical brick tower, standing on natural rock. It was aligned with the Fort Qait Bey limit, and used to mark a dangerous rocky area at the entrance of the seaport of Alexandria [Jondet 1916]. The tower no longer exists. It was last recorded in 1916. However it is not known if the Tour de la Mission d'Egypte was lighted or not. Figure 13

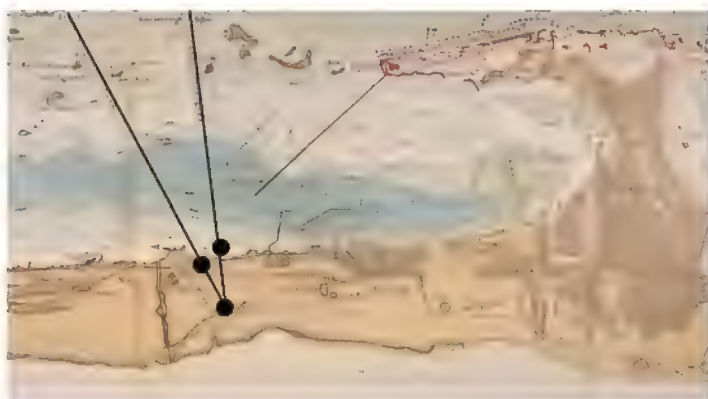


**Figure 13:** Tour de la Mission D'Egypte *source: Jondet, Gaston, M.*



## 7. Relation to other lights in the area

The placement of lighthouses should follow the topography of the area. Aligning two fixed points on land provides a navigator with a line of position called a range. Ranges can be used to precisely align a vessel within a narrow channel. If the landmarks of a range are illuminated with a set of fixed lighthouses, navigation can also be done at night. Such paired lighthouses are called range lights. Two lights are used in this scheme. The one closer to the vessel is named the front range; the furthest away is called the rear range. The rear range light is always taller than the front range light. When the vessel is on the correct course, the two lights line up above one another. The placement of the Mex lighthouses, the low and high lighthouses, follows this rule. The Mex Old Lighthouse also had a range light with the Mex High Lighthouse have indicated one of the two paths to enter the port of Alexandria. In this case the high range light was playing a double role determining the two passages. This role became obsolete when the Mex Old Lighthouse was switched off. Figure 14.



**Figure 13:** Map of Alexandria 1912 illustrating the relationship of the Mex lighthouses with other lights. The lines mark the safe passage in and out of the harbor avoiding rocks and other obstacles  
source: Jondet.

## 8. Concluding remarks

After studying the lighthouses of Alexandria a crucial question arises: are the lighthouses of Alexandria worthy of conservation? The lighthouses of Alexandria have made a significant contribution to maritime history; they embody distinctive characteristics and represent a unique building type and method of construction. According to the listed buildings prepared by the Governorate of Alexandria according to law 144/2006, Ras El Tin lighthouse is registered as a listed building under number 1710 and Montazah Lighthouse under number 2019 as a national landmark. They are listed as structures of special architectural merit. This implies that only these two structures are protected by law leaving out the other lighthouses which are not registered to their gloomy fate. Recent changes in the purpose of lighthouses and the advancement of navigation technologies may make lighthouses obsolete. Therefore, the research recommends that the lighthouses less essential to navigation should be transformed into observation towers within a development plan of their urban setting administrated by local governmental and private non-profit organization.

### Future research:

- Comparative analytical study of the architectural elements of lighthouses of Alexandria.
- Conservation and restoration plan of the reuse of Alexandria's lighthouses by studying each lighthouse within a detailed study of its potential, existing condition and development potentials.
- Comparative architectural study of the lighthouses of Alexandria and other lighthouses of the Mediterranean in terms of shape, building materials and decorative elements.

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<http://www.unc.edu/~rowlett/lighthouse/egy.htm>, posted July 25, 2006. Checked and revised July 14, 2007. Lighthouses: 29. Site copyright 2007 Russ Rowlett and the University of North Carolina at Chapel Hill.

# INNOVATIVE HIGH-RESOLUTION, BUBBLE IMPLOSION BASED ULTRASOUND APPARATUS FOR SUBMARINE ARCHAEOLOGY

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## Abstract

An innovative echographic system for marine exploration particularly suitable in archaeological research is presented. It is an improvement of a previously designed device in the frame of the Italian "Special Project for the Safeguard of Cultural Heritage". The main novelty, recently object of international patents, consists in a paraboloidal sparker source where the electrostatic energy is concentrated in one single pulse, thus providing a more powerful acoustic pulse and a wider frequency band extending from some kHz up to about 400 kHz, useful for high resolution. After a few tests to calibrate the system in the laboratory tank of IDAC and in a sea-basin, prospectings in the Venice Lagoon were carried out. Here important remains of the ancient Roman Port of Altino were revealed.

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**Keywords:** Submarine archaeology, Echographic apparatus, Venice Lagoon.

## 1. Introduction

Acoustical techniques for explorations into deep sea subbottom had a remarkable development from oil-research, mainly concerning acoustical signal processing, while no substantial contribution has been given to the improvement of resolution of the prospecting systems. Actually, oil-research is interested to large-scale anomalies connected with the profitable big oil-fields, for which resolution is not an important requirement. On the contrary, the exploration of shallow sea subbottom (from a few to tens of meters) needs high resolution in order to reveal small anomalies and objects. Detecting subbottom sediment structures and archaeological objects is a very important topic, especially for the Mediterranean Sea Basin. Actually, in this area, the succession of manifold geological events, which caused submersion of secular strata of various civilization man-made structures, and thousands of shipwrecks from the ancient age to today, render the top layers of the sea bottom particularly interesting. The presence of archaeologic remains on the sea subbottom is often correlated to particular marine environment situations, so their detection and unearthing also help to investigate the geological characteristics of the submersed sites, as well as to enrich the historical heritage of the neighbouring countries.

The system here presented can be advantageously used in a wide range of applications involving the submarine environment. Really, the present echographic system fits adequately two mandatory requirements in marine sediments explorations: high resolution (i.e high frequency at sufficiently high power) to resolve small-dimension objects buried in sediments and lower frequency at high power to penetrate deeply in sea subbottom. As concerns marine archaeology, where shallow sea subbottom explorations, namely a range from a few to tens of meters, are involved, high-resolution is a compulsory requirement in order to reveal also small anomalies and antique objects.

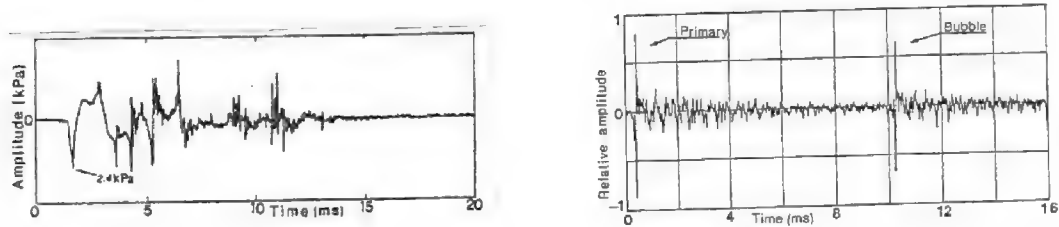
## 2. Description of the apparatus

A compromise between resolution and penetration has been achieved in the present prototype of echographic system, initially developed at the Istituto di Acustica "O.M. Corbino"(IDAC), in the frame of the Italian "Special Project for the Safeguard of Cultural Heritage" and recently improved [1] to optimize resolution and power, exploiting the physical phenomenon of bubble implosion [2]. The system consists of two paraboloidal transducers: the transmitter, a pulsed sound source exploiting the implosion of a vapour bubble generated by an electric spark at its focus, and the receiver with a piezoelectric ceramic at its focal point to detect signals reflected by sea subbottom targets.

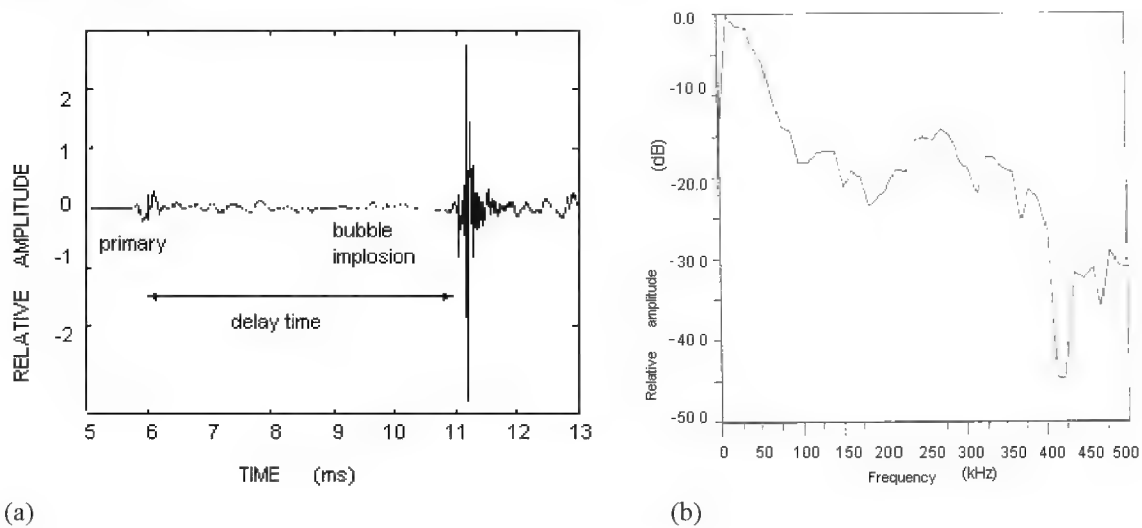
The paraboloidal source is characterized by more controllable acoustic signature which makes it more versatile in comparison with traditional sparker devices. Generally, the sparker source generates a primary pulse followed by one or more cavitation bubble pulses which appear randomly in time (Fig.1,left). Instead, in the paraboloidal source (Fig.1,right) the electrostatic energy is divided in a primary and in a secondary pulse due to bubble. A successive innovative improvement was made, for suitable values of electrodes distance and electrostatic energy, which minimizes the primary pulse, allowing the acoustic energy to be concentrated in a single intense pulse generated by the implosion of the vapor bubble at the focal point of the paraboloid (Fig.2a). This new acoustic source significantly improves the spectrum in the lower frequency band, showing very intense components up to 50 kHz, and providing an almost flat frequency spectrum from 100 kHz to about 400 kHz, within a few dB (Fig.2b). So, it fits adequately the above two mandatory requirements in marine sediment explorations: high resolution (i.e high frequency at sufficiently high power) to resolve small-dimension objects buried in sediments and lower frequency at

high power to penetrate deeply in sea subbottom. Fig.3 shows the experimental prototype of the two transducers of the echograph in the laboratory tank of the IDAC, while Fig.4 shows a schematic view of the whole apparatus working.

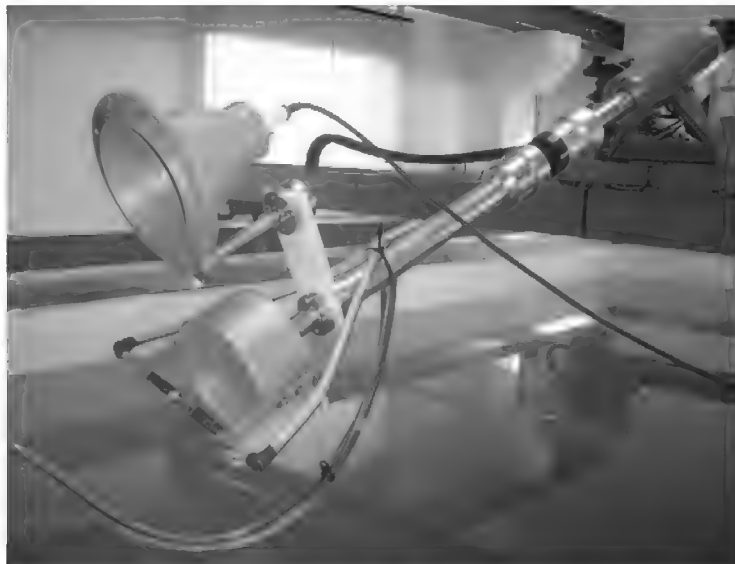
The apparatus includes a parabolic transmitter which is associate to an electronic control unit and spaced apart from the receiver by an appropriate distance, which is adjustable according to the prospecting depth. The transmitter is energized by means of a condenser bank forming part of the control unit and converts the electrostatic energy into acoustic energy in the form of a single intense pulse.



**Fig. 1** - Acoustic signal generated by a traditional sparker source, at left, and that generated by a paraboloidal source, at right.

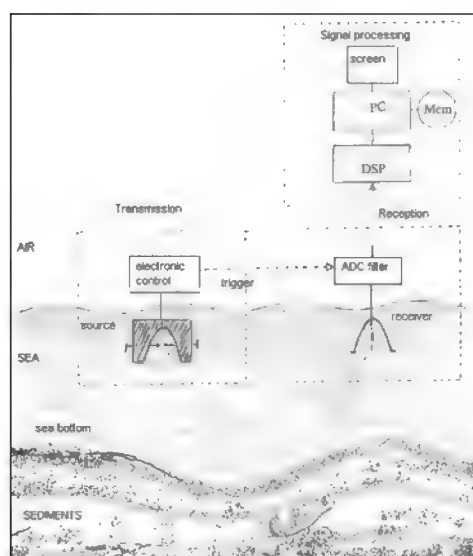


**Fig. 2** – Signature of the bubble based paraboloidal transmitter in the time (a) and frequency domain (b).



**Fig.3** – Experimental prototype of the two transducers of the echograph at the tank of the IDAC - Underwater Acoustics Laboratory.





**Fig. 4 - Schematic diagram and comprehensive view of the echographic system working.**

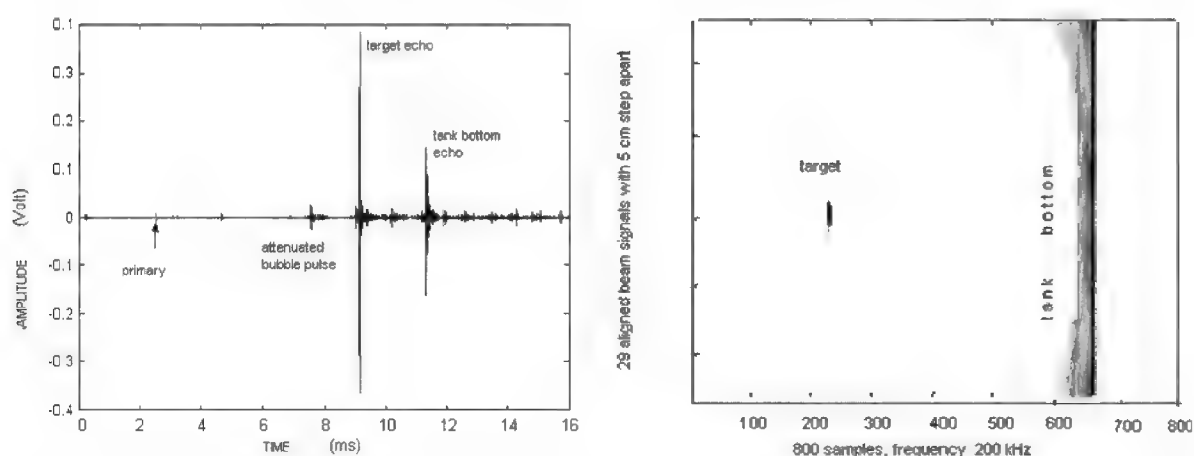
The signal reflected by sea subbottom target is received by the reception paraboloid which is connected to an analog- to- digital converter (ADC) that transmits the digital data to a microprocessor card (DSP) in order to perform the successive processing by a dedicated PC. At last, the result of the survey is shown on the display in form of an acoustic image of the detected object.

### 3. Physical principle and laboratory tests

The phenomenon of bubble implosion is at the base of the echograph design and it was fully studied at the tank of IDAC laboratory (Fig.5) by means of optical and acoustic measurements using high-speed camera and laser vibrometer, respectively. Results [ ] allowed the following interpretation.

After closing the electric circuit, an initial breakdown discharge happens. The considerable rise in electric current in the small volume of spark gap between the electrodes heats up the water at very high rate and causes the violent growth of a vapor bubble, a shock wave, appearing in the time oscillogram as a primary pulse. The phase of very violent outward motion is very short –lived (*lived*), and is followed by an inertial expansion that brings the bubble to a maximum Radius,  $R$ . After this, the bubble starts to implode with a progressively faster inward motion which is very violently reversed by the sudden pressure increase. This is the cause of the large pressure pulse observed after the delay time, called bubble implosion pulse (Fig.2a). Most electrostatic energy is converted into the acoustic energy in form of this intense acoustic bubble implosion pulse. In this conditions the echograph reaches a maximum efficiency given by the ratio between the acoustic energy and the supplied electrostatic energy.

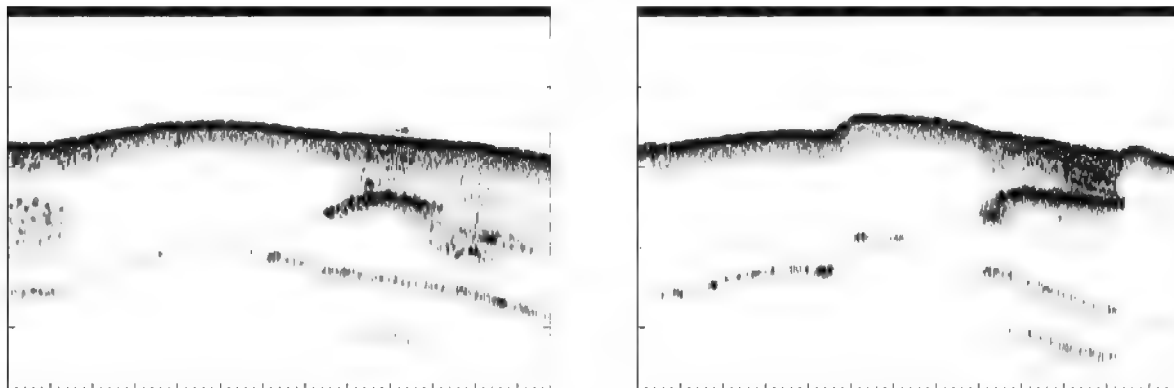
A series of tests were carried out to obtain imageries of some targets dipped in the tank water. An example is reported herein. The apparatus was arranged in the prospecting layout with both the transmitter and the receiver apertures facing the tank bottom and a scanning was performed above a target consisting in an air filled plastic cylindrical tube with 14 cm diameter and 2 m length. Results are shown in the graphs of Fig. 5.



**Fig. 5-Time domain signal corresponding to a position of a 29-step scanning of the echographic system above a target into the tank water and corresponding acoustical imaging of the target (at right) .**

#### 4. Prospecting in the Lagoon of Venice

The first sea-basin test were carried out in an undisturbed Lagoon area of Venice about 200 m South-West of S. Giacomo isle. This isle already inhabited in the Middle Ages is deserted today. Here a few experiments were performed to test the echographic system in real working conditions. Then, an extensive prospecting campaign was performed in the Nord Lagoon in the frame of the ECHOS project [2]. Herein, only an example of typical result is reported, corresponding to the exploration of the area where in the ancient age some Roman villas existed. Prospectings revealed remains of the ancient Roman Port of Altino (Fig.6) .



**Fig.6-** Parallel prospectings 5 m far away in the Scanello Channel (North Lagoon of Venice ), about 1 km East of Burano Isle. The framed area correspond to a depth of 9 m, and length of 50 m. A vaulted structure is evident at about 1.5 m under the shoal, most likely remain of the ancient Roman Port of Altino.

#### 5. Conclusions

The echographic system, based on the bubble implosion mechanism, shows features not available in current sonar-like devices. It allows conversion of electrostatic energy into acoustic energy, in form of a very powerful acoustic pulse at high efficiency and wide frequency band, which fully meets requirements for submarine explorations in different environmental conditions and situations. Archaeological exploration needs two requirements which are often antithetic: high-resolution to reveal small dimension remains buried in sediments, and penetration capability for deeper prospecting in the seabottom. High-resolution requires a high-frequency, broadband signal; while penetration demands use of powerful sources in the low frequency band. The prospecting campaign carried out by IDAC with the collaboration of “Istituto di Scienze Marine”, CNR, showed that interesting archaeological constructions and objects can be revealed in the sediments of Venice Lagoon, such as ancient artifacts and remains, as well as geologic structures. This was the first attempt to conduct an extensive survey by acoustic techniques, aiming at producing a geoarchaeological map of the Lagoon in the frame of ECHOS project sponsored by the Water Magistracy of Venice.

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# HISTORICAL CITIES OF NORTH CYPRUS – initiative to revitalize Kyrenia city

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## Abstract

North Cyprus is a small developing country with an overwhelming historical and cultural heritage. It is a country with problems, which characterize every developing country where protecting heritage is not in the priority list. Assigning a definition to a monument and identifying its location is the first step to the process of its preservation.

Base of this article: The researches and analyses for STREMAH 2009 -“Sustainable city planning - preserving historical objects” (where the definition of NMAS – non-monumental antique structures was given and the mechanisms of their classification according to their values were invented).

The aim of the research: this article conveys the methods of the practical implementations of the above stated mechanisms, targeting the identification of the transformation in building functions, structures and street image that are not yet protected, their classification and registration as structures needing protection.

Subject of research: North Cyprus, city of Kyrenia, Jafer Pasha Street.

Step by step solution: historical cities of North Cyprus were listed and examined; detailed inspection of the city of Kyrenia and its Street of Jafer Pasha was conducted; antique non monumental structures were located, their classification, changes in their physical appearance and functionality were identified.

**Keywords:** historical city, preserving heritage, non-monumental structure, North Cyprus, Kyrenia

## INTRODUCTION

The island of Cyprus stands at the crossroads of Africa, Asia and Europe and its history dates as far back as the Neolithic Age. Although a small country, North Cyprus has an overwhelming cultural heritage. Wherever you travel - you will find ancient monuments and sites, churches and monasteries bearing silent witness to over 3,000 years of civilization and history.

Due to its geographical location in the Mediterranean, the island has always been a link between the Mediterranean countries. The climate and geography of Cyprus have always been attracting conquerors from various civilizations and of different religions, who affected the architecture and culture of the island to a great extent. To pass over the cultural and historical wealth to the future generations through conserving, revitalizing and renewing them - is a task of prime importance of the today's nation, even in a developing country, such as North Cyprus.

The value of the analysis: Since North Cyprus is a small developing country with problems which characterize every country as such and protection of the heritage monuments isn't a priority list ingredient, solving the issues of identification and selection of antique buildings needing protection in historical cities would only be possible through collaborative works of historians, archaeologists, architects, artists, country's citizens and its government. Detect the structures, which are yet neither considered as monuments nor placed under protection of the government; register them in the Land Registry Offices and archives – these are the actions to be taken in order to make the first step toward the process of historical city revitalization.

TABLE I. Historical Cities of North Cyprus

North Cyprus map	City's name	Year of foundation	Population
	Nicosia	300 B.C.	62 000
	Famagusta	285 B.C.	54 000
	Kyrenia	10th Century B.C.	38 000
	Guzelyurt	Middle Ages B.C.	27 000
	Lefke	3rd Century B.C.	6 490

Base of the article: The researches and analyses for STREMAH 2009 -“Sustainable city planning - preserving historical objects” (where the definition of NMAS – non-monumental antique structures was given and the mechanisms of their classification according to their values were invented) [1].

The aim of the research: this article conveys the methods of the practical implementations of the above mentioned mechanisms, targeting the identification of the transformation in building functions, structures and street image that are not yet protected, their classification and registration as structures needing protection.

Subject of research: North Cyprus, city of Kyrenia, Jafer Pasha Street.

Kyrenia is a third biggest city of North Cyprus, however according to the number of tourists it receives annually - it beats all the cities on the island. Due to its location on the seaside, historical identity and Harbor, Kyrenia has been a touristic city for long period of time. The Harbor, in the past, was used for lighters and long shore boats, and the city was built around this horseshoe shaped Harbor. The main attractions of the city include its Castle and Harbor [2], see Table XI. Even though different civilizations and cultures left their trace in the formation of the specific and unique image of Kyrenia, it still has preserved its initial function (it has been a commercial port) and up till today is one of the biggest ports of the country [3].

Jafer Pasha Street has been chosen as an object of analysis due to the fact that it is one of the longest streets of Harbor, which is rich in variety of structures/functional features, as well as architectural, cultural and historical values. Buildings on this street have been examined, classified by functional uses; the street transformations and changes in the façades of the buildings' in the past 10 years have been thoroughly analyzed; the structures, which are potential NMAS were identified, and finally, conclusions were drawn with recommendations for the rehabilitation of the street image and recuperation of buildings.



Step by step solution: historical cities of North Cyprus were listed and examined; detailed inspection of the city of Kyrenia and its Street of Jafer Pasha, antique non monumental structures were located, their classification; changes in their physical appearance and functionality were identified.

### GENERAL CHARACTER OF THE STREET

Territory of the Harbor is composed of narrow streets, built in an organic layout, within which the buildings are literally glued to each other. These kinds of streets reflect the spatial connection between houses, nature and human scale, and until today have preserved the local identity [4]. The common wall connecting the houses played not only an environmental and aesthetical role; it was an element of traditional Cypriot architecture, which is called passive design today. The wall was protecting houses and courtyard from cold wind in the winter and served as a sun shield in the summer.

Jafer Pasha Street, which earlier carried the name of Justinian Street, was selected as object of research for a reason: it is one of the longest streets of the Harbor. The entry to Jafer Pasha Street is facilitated from Merdinci Street (old name - Nikiphoros Fhokas Street), which leads to the Inner Harbor and the sea, flowing downward to Atilla Square (previously called Hermez Street), which connects 5 streets. The street is strictly pedestrian, and houses are only 1-2-storey buildings with flat roofs, attached to each other, forming a single continuous curve. All the houses are colored in white or subtle tones, which only compliment the single spatial composition. Almost all the structures on this street were erected during the early and late British period, with particular features typical for that particular period of time [1], [5].

TABLE II: Street's Map

Street's map with buildings' elevations	Entrances to the street
	

The majority of the houses on the street has preserved its' initial functions and are residential. Among the residential houses there are as well 4 restaurants (one of which is currently not in use), 3 hotels (one of which is deserted), 2



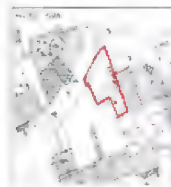


offices, 2 shops and one mosque. Even if we take into consideration the multiple functions of the structures available on this street, it still is not enough to attract the local visitors and tourists. In order to improve the street's image, rise its' cultural value and return Kyrenia Harbor its identity, an architectural and structural analysis of the houses located on Jafer Pasha Street (section of the street between the intersections with Denizciler/Chrysopolitisa street and Atilla/Hermes street) was conducted, and the transformation of buildings' structure and street image as a whole was considered as well.

TABLE III: Buildings' functions

Building's present function	The amount of buildings on Jafer Pasha street with similar functions	Numbers of the buildings
Residential house	9	4; 5; 6; 8; 13; 14; 15; 16; 17
Restaurant	4	3; 4; 12; 19
Hotel	3	2; 9; 11
Office	2	18; 20
Shop	2	7; 10;
Mosque	1	1


## ANALYSIS OF THE BUILDINGS ON THE STREET

TABLE IV: Analysis of the building № 6

Building's location	6, Jafer Pasha			
Year of construction	1960 - 1974			
Original function	Residential			
Architectural style	Cypriot			
№ of floors	Two			
Wall material & construction method	Brick, masonry			
Roof type and material	Flat, concrete			
Exterior features	Wooden windows/doors, Cypriot style shutters, wall common with other buildings			
Reconstruction works	Wall covered by plaster, roof reconstruction, alterations			
Changes after reconstruction	Misbalance between windows', doors' & whole house proportions in the elevations			
Present function	Residential			
Building's present condition	Constructions - good, presence of moisture in the house			
Suggestions	Has no claim to be defined as NMAS, has environmental texture value			


It is essential to note that the city archives have not preserved any information about buildings on Jafer Pasha Street. The information presented in this article is based on site inspection by authors, detailed examination on an element-by-element basis. Information on buildings' age, style, original function, construction materials and methods, exterior and interior elements and building present condition was provided by means of inspection for each building. Some useful information has been obtained through interviews and discussions with representatives of City Planning-Antique & Museum Offices and through discussion with owners of inspected buildings.

TABLE V: Analysis of the building № 7

Building's location	7, Jafer Pasha	
Year of construction	1878 - 1930	
Original function	Residence & shop	
Architectural style	Early British period architecture	
№ of floors	One	
Wall material & construction method	Stone, masonry, covered by plaster	
Roof type and material	Clay tile plain roof	
Exterior features	Wooden windows/doors, shutters, wall common with other buildings	
Reconstruction works	Yes	
Changes after reconstruction	Doors/windows' forms changed, style of the house preserved	
Present function	Traditional store	
Building's present condition	Constructions - very good, exterior and interior - good	
Suggestions	Potential NMAS, example of typical double function building of Early British period	

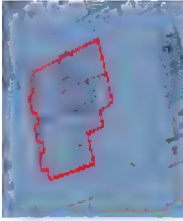


**Buildings' Height:** The corner building № 9 on the street carries a dominant skyline feature and starts a line of buildings on the street, connecting them between each other. The height of the buildings is one and two storey. There were no editions in buildings' heights and the original scale of the street has been preserved.

TABLE VI: Analysis of the building № 8

Building's location	8, Jafer Pasha	
Year of construction	1930 - 1960	
Original function	Residential	
Architectural style	Late British period architecture	
№ of floors	One	
Wall material & construction method	Stone, masonry, covered by plaster	
Roof type and material	Plain asphalt shingle	
Exterior features	Wooden windows/doors, Cypriot style shutters, wall common with other buildings	
Reconstruction works	No	
Changes after reconstruction	No	
Present function	Deserted	
Building's present condition	Constructions-good, exterior/interior - poor, presence of moisture in the house	
Suggestions	Potential NMAS, example of typical residential house of Late British period	

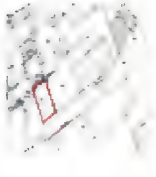


**Buildings' Age:** All the structures were analyzed in a way that their age and style were determined basing on their construction material and methods, exterior and interior design, typical characteristics and features. The oldest building on the street was built between 1878 -1930, during the Early British period. This shows that the street planning commenced in that particular period of time. The rest of the buildings were built between 1930 -1960 and represent the Late British architecture. They are of the same style and form a unique ensemble.

TABLE VII: Analysis of the building № 9

Building's location	9, Jafer Pasha			
Year of construction	1932			
Original function	Hotel			
Architectural style	British Colonial			
№ of floors	Two			
Wall material & construction method	Stone, masonry			
Roof type and material	Flat, concrete			
Exterior features	Architraves, pilasters, balustrade balconies, belt courses, bent courses on doors and windows			
Reconstruction works	No			
Changes after reconstruction	No			
Present function	Hotel			
Building's present condition	Constructions-very good, exterior-poor, interior-poor, presence of moisture			
Suggestions	Potential NMAS, having historical, architectural and environmental value			

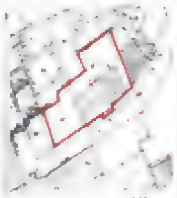


**Buildings' Use and Occupancy:** Building usage is a key indicator to the overall health of the street building fabric. The majority of the buildings on the street are residential; there are as well two hotels, few dual purpose structures (residential/shops), proving that originally the street was residential. Only one building on the street, originally residential, is now deserted. Almost all the buildings have preserved their original function.

TABLE VIII: Analysis of the building № 10

Building's location	10, Jafer Pasha			
Year of construction	1930 -1960			
Original function	Store			
Architectural style	Late British period			
№ of floors	One			
Wall material & construction method	Stone, masonry, covered by plaster			
Roof type and material	Clay tile plain roof			
Exterior features	Well expressed features of door and large arch framed windows			
Reconstruction works	Yes			
Changes after reconstruction	Walls re-plastered, roof reconstruction, building has preserved its style and originality			
Present function	Store			
Building's present condition	Construction-very good, exterior and interior very good			
Suggestions	Potential NMAS, having historical and cultural value, require restoration			




**Building materials and constructions:** The buildings are made of stone and masonry construction technique, which are both characteristics for the British period architecture. Roofs are plain and flat, clay tile or asphalt shingle. Some buildings are covered by plaster.

TABLE IX: Analysis of the building № 11

Building's location	11, Jafer Pasha			
Year of construction	1930 - 1960			
Original function	Residence & shop			
Architectural style	Late British period architecture			
№ of floors	Two			
Wall material & construction method	Stone, masonry, covered by plaster			
Roof type and material	Flat, concrete			
Exterior features	Wooden door, small windows with shutters, small balcony			
Reconstruction works	Yes			
Changes after reconstruction	Walls re-plastered, roof reconstruction, building has preserved its style and originality			
Present function	Hotel			
Building's present condition	Construction-very good, exterior and interior very good			
Suggestions	Potential NMAS, has value as a typical example of residence and shop of Late British period			

Buildings' interior and exterior: The buildings are single rectangular in plan, with common living area in the middle of the house, connected with the rest of the rooms. Each building has an open courtyard, surrounded by a wall, common with other buildings on the street. The windows are small and high, located on the facade. Wooden doors, and windows with shutters outside for sun protection. Small balconies projected from the second floor, with "I" shaped supports.

TABLE X: Analysis of the building № 12

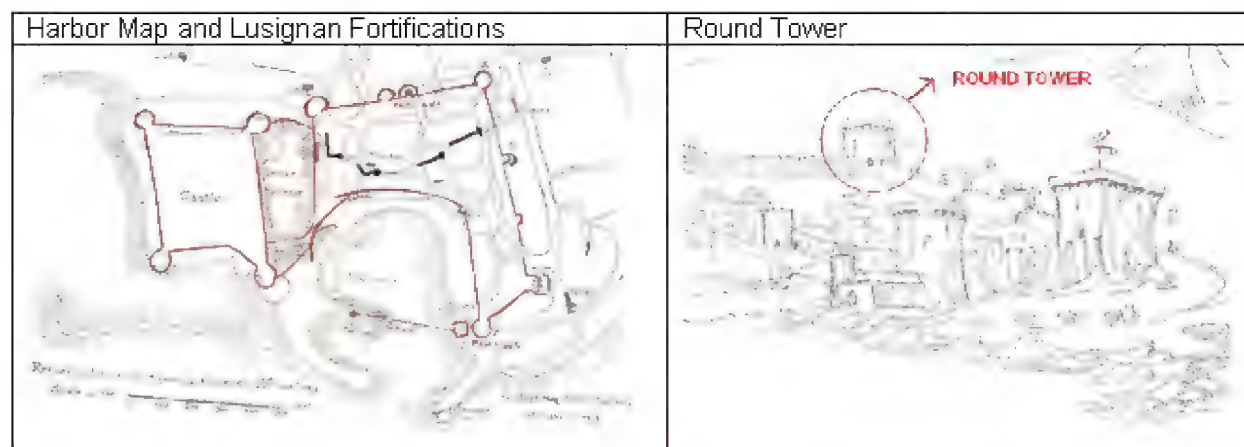
Building's location	12, Jafer Pasha			
Year of construction	1930 - 1960			
Original function	Restaurant			
Architectural style	Late British Period			
№ of floors	One			
Wall material & construction method	Stone, masonry, covered by plaster			
Roof type and material	Plain clay tile			
Exterior features	Wooden door, small windows with shutters, small roof skirt for rain protection			
Reconstruction works	Walls re-plastered, roof reconstruction			
Changes after reconstruction	Some changes in doors/windows details, building has preserved its original style			
Present function	Restaurant			
Building's present condition	Constructions-very good, exterior and interior-good			
Suggestions	Potential NMAS, has value as a typical example of Late British period restaurant			

## RESULTS OF STREET ANALYSIS

The high value of Jafer Pasha Street is characterized through a few factors : the street is located on the territory of the Harbor, which is a historical part of the city; this particular street is the longest street of Harbor; the street traces a path from the sea to the Inner Harbor (which earlier carried the name of Hermes Street - now Atilla) and Round Tower [2], connects 5 streets of Harbor; the street is clearly visible from the square and consists of structures built during the early and late periods of the British Architecture, see Table XI.



TABLE XI: Harbor Map and Lusignan Fortifications and the Round Tower



Environmental value of Jafer Pasha Street is represented by the fact that the entrance to the street opens from the square with the Round Tower, built in 13<sup>th</sup> century by the Lusignans as a corner of fortifications protecting the Harbor from attacks, which raises above all the structures, uniting them with the boulevard and completing an architectural ensemble [2], see table XI. The street, due to its value, should be preserved, revitalized and given a chance to play its' role in the cultural tourism, which is up-to-the-minute today [8].

According to the results of the Street's analysis, the majority of the structures are traditional buildings of the early and late British Architectural Style. Meticulous indicators of this particular style include petite 1-2 storey structures, built of stone, some covered by plaster, having a flat roof and small balconies on the second floor, supported by "S" or "I"-shaped ornamented structural supports, entrance to the house – usually in the middle of the front façade, timber worked two wings doors, vertical narrow windows with timber shutters. Typical extension of a house is a little courtyard with fruit trees at the back of the house [5]. Certain houses on the street are presently in a very poor condition (external and internal constructions, including the roof), some being in a relatively better condition than others, however during the process of their restoring the typical features of the buildings have been changed, which in its' turn has affected the original identity of the street and reduced its appeal. The streets' flooring is parquet, which requires restoration works as well. Sound landscaping, including details that usually complete the environment of the street (road signs, benches etc.) - fully lack. Since the houses are semi-detached and form a fused ensemble alongside the street, it is crucial to preserve each house, while restoring individual building the professionals should conform to the master plan for revitalization of the street as a whole [9].

Since the only administrative organ responsible for preservation and city planning is City Planning-Antique & Museum Offices, non-existence of the laws protecting NMAS, as well as their reconstruction, lack of archival information about time and conditions of construction works. The trouble is made more severe by the fact that the buildings belong to the private owners. Taking into consideration the above stated factors, it is clear that a real problem exists in the results of the buildings' reconstruction works, structures' preservation and street revitalization [10].

## CONCLUSION

It is crucial to analyze and agree with the fact that the quality of urban environment has suffered a loss and that the gains of redevelopment have not made up for the losses. In addition, where changes have taken place through alteration, rather than complete redevelopment, the general standard and quality of the new work has rarely contributed beneficially to the street scene.

There is a necessity of cardinally changing and reviving the quality of design for preservation of the original identity of the place. Final destination being clear: increasing the number of visitors, which in its turn would mean customers, as a historical city should be not only a subject of research, but also a place, offering its visitors pleasure, accessibility and convenience [11],[12].

After examining and analyzing the present condition of the Jafer Street, the following suggestions for the buildings' restoration and reviving the street's initial attractiveness have been given:

- a) Administrative solution methods:
  - ✓ Comply a City Archive, in order to systematize and preserve complete information about the monuments and structures identified as potential NMAS
  - ✓ Register all structures located on the Harbor territory identified as potential NMAS
  - ✓ Under the patronage of City Planning-Antique & Museum Offices there should be an additional authorized administrative organ formed, which would control all the reconstructive, restoring, and revitalizing works on structures in Harbor, and each individual NMAS
- b) Practical solution methods:

- ✓ Taking as an example the Jafer Pasha Street, examine and analyze Harbor area, each street and each building on it with a scope of identifying the factual value of each structure
- ✓ Conduct an analysis and systematize all the data regarding transformations which were incurred by the structures and streets under the influence of time and reconstructions, for their future revitalization.
- ✓ All the data acquired should be passed over for its' registration and preservation to the newly complied City Archive, as well as to the relevant administrative structure for identification and formulation of a Harbor revitalization plan.

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## ORTIGIA ISLAND (SYRACUSE) FROM THE STATE OF DAMAGE TO THE REUSE.

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### Abstract

Our work wants to highlights the process of mutation which have determined an evaluation of Syracuse's historical centre . Our work is divided into four paragraphs. In the first one, as an introduction, in general, the main stages of the island history. In the other three steps, we will deal with three basic of the question related to the historical centre, as to say the urban, the socio-economic and the cultural.

It will carry out a wide exhibition of all factors generally used as indicators objectives in the research of the quality of an urban environmental but will be taken also into consideration some objective aspects related to facts, events and reflection to characterize the cultural picture.

A particular attention will be taken to the themes connected to the relation of the insider – outsiders, to the live condition, environmental condition, to the social condition and finally to the life quality, that it is contained within Ortigia perimeter. To conclude, it will be pointed out ideas and suggestions for a better urban planning.

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### § 1 Geographical setting and brief history

Thanks to its central position on the south-eastern Ionian coast of Sicily, Siracusa has an ages-old history of settlements that testify to the elective role the city has played, since far-off times, in the vast territory of the Val di Noto, defined in the course of the Arab-Norman epoch. A dense network of watercourses rising from Monte Lauro, the most important mountain in the Ibleo upland chain, cross the whole area before reaching the sea, like the ribs of an immense seashell. The Simeto to the north, the Salso to the south and the spurs of the Erei range to the west are the geographical elements defining the natural borders of the Val di Noto territory, which is karstic in the centre and alluvial on the edges. This characteristic helps to explain the pattern of human settlement over the area as a whole and Siracusa in particular, which divided the shepherds of the inland plateau from the Greek colonisers, the mountain society from the colonies on the coast. The most ancient signs of human settlement in Siracusa date back to the Middle Bronze Age (XIV century BC) and continue without interruption to the Iron Age when the first contact between the native inhabitants and the Greeks took place with intense cultural and commercial exchanges, giving rise to the city's most important historical phase which started in 780 BC. A reliable historical tradition dates the foundation of the city to around 734 BC, the work of a group of Corinthian colonisers who settled on the island of Ortigia and in the area of the Siracusa Forum. These two original embryo settlements continued to develop until by the VI century BC they had become an imposing stable structure. In this epoch, Siracusa could be considered the most important city in Sicily on a par with Athens, the most important city in Greece.

Originating as a Greek colony, highly dependent on the motherland, with an influx of new colonisers, Siracusa quickly became an independent entity, an influential, commercial 'pentapolis' within the Mediterranean, but also a vast city of great architectural worth, as well as the seat and heart of the classical civilisation which still today seeps from the complex layers of the urban landscape. Just think of the majestic Athenaion, the temple of Minerva, whose remains are still recognisable today even though they form part of the Cathedral dedicated to the cult of Santa Lucia. From a military point of view, even in the V century BC, the whole Mediterranean considered Siracusa to be impregnable, with one of the most extraordinary fortification systems of the time, Castello Eurialo, also the palace of Dionigi the Old (405 – 367 BC) the tyrant who built it, which then became an acropolis. Siracusa was a strong Greek city, the undisputed capital of the Mediterranean until its defeat at the hands of the Roman Consul Marco Claudio Marcello (214 BC). During the Imperial Age Siracusa began to decline: the residential areas on the mainland contracted, it was progressively stripped of its art treasures and became more and more impoverished, even though it remained an important urban centre and chief town in eastern Sicily. From this moment on, there were alternating periods of economic and artistic flourishing and decay. It was sacked by the Franks in 278 AD and by the Goths in 493, captured by the Byzantines in 535 and then underwent Arab dominion for two centuries after being conquered in 878. During this period the city's territorial area reduced until it consisted almost only in the island of Ortigia. In 1038 the Greek captain Giorgio Maniace freed Siracusa from Arab dominion and left the sign of his conquest in the imposing castle named after him on the farthest point of Ortigia. Centuries of intense history followed during which the fate of the city depended – as never before – on that of Sicily, subjected to Norman, Aragonese, Angevin and Spanish dominion. Apart from the figurative language of the civil and religious architecture that characterised each period, the urban fabric and buildings of the city did not undergo particular change. Even when the terrible earthquake of 1693 struck the province, with its epicentre in Carlentini, no irreparable damage was caused, unlike other cities which were razed to the ground and rebuilt ex novo. This correspondence between the borders of the Siracusa province and the area affected by the earthquake is at the basis of its territorial homogeneity, which rose from the ruins in Baroque style, specifically interpreted by each individual

town in the Val di Noto. The restoration of the damaged heritage, some partial substitutions and the new buildings gave Siracusa a typical seventeenth century aspect, which witnessed the renewed prosperity of the city. It maintained its splendour for about a century and nothing could have foretold the town and building crisis which would follow.

## **§ 2 The decline of Siracusa and Ortigia: from sprawling industrialization to real estate speculation**

The first real signs of decline date back to 1865, when Siracusa became the chief town of the province once again. There followed a favourable period of economic growth and the population increased.<sup>1</sup> As a consequence, the demand for real estate grew and uncontrolled, intense speculation began. The urban features of Siracusa, still enclosed in its fortified walls, changed as it developed both vertically (with high buildings) and horizontally (with the urbanization of free areas outside the walls) all without any form of planning.

As if this was not enough, part of the architectural heritage of the city, consisting mainly in cloisters and monasteries, changed its original, precious architectural appearance after a law was passed that transferred this property to the state and provided renovation works so that these buildings could be used for civil purposes. The most relevant, but negative event that modified the original historical landscape was the demolition of the Spanish fortifications and the channel filling works (1886-1893). The resulting large, reclaimed area was transformed into an orthogonal mesh road network. Other demolitions followed in Ortigia too, with the aim of creating space to be used for modern buildings. The 1943 air raids also caused considerable damage to the built-up areas and the ancient architectural heritage.

In the first decades after the Second World War, a large part of the Siracusa - Augusta coastline was characterized by huge industrial development. The whole of Italy was, in fact, experiencing the first stage of an industrialization policy which aimed at establishing new areas of industrial development (with the support of the "Cassa del Mezzogiorno" set up by the government to revive the economy of the south) in peripheral areas like Sicily. These were considered strategic areas because of their natural resources and favorable geographical characteristics. In the static, archaic and still largely rural social context in Siracusa (as in many other Sicilian provinces), which was far removed from a purely economic approach, the presence of the petrochemical pole seemed the best way of slowing down the phenomenon of emigration from the depressing reality of the city. The industrialisation of this one-time, proud city was, therefore, supported and considered the only chance for an economic and social renewal. However, the close relationship between the epoch-making event of industrialization and the transformation of the landscape, environment and urban areas led to immediate problems, some of which have still not been resolved yet. The first catastrophic effects of industrialization in Siracusa affected the appearance of the coastal landscape, thereafter degraded and irreparably compromised. Today this situation continues to create indignation in anyone driving along the highway from Catania to Siracusa when, approaching Augusta, Priolo-Melilli and Siracusa, the petrochemical chimneys appear on the horizon and rank fumes pollute the air. The environmental damage is irreparable: air pollution, organic pollution of the sea, eutrophication of waterways and groundwater contamination. Moreover, while industrialization and its offer of new job prospects and better earnings made people move from the countryside (which represented the values, experience and traditions the city of Siracusa was progressively losing) to the city, the unexpected economic growth also modified the urban landscape with illegal urbanisation. From the first decade of the '50s, the city spread in the direction of the mainland going beyond its borders and generating new residential suburbs. And beyond them, along the coastline from Siracusa to Cassibile, many 'second homes' for holiday use were illegally built with no planning permission. New hotels and restaurants were also built in privatized areas aimed at developing tourism. Nothing strange in this, that the city should exploit its position by the sea, if it had not been that in the great majority of cases there was land speculation and damage to an irreparable heritage: the landscape. In fact the striking coastline, that had for centuries been enriched by its natural inlets, sea springs and luxuriant vegetation, was seriously compromised. At the beginning of the '70s Siracusa was faced with an increasingly complex touristic situation: the development of the so-called "three- S tourism" (Sun, Sea and Sand) which promoted the building of new holiday camps, mainly for foreign visitors. This was one of the most serious episodes of land speculation that, more than in the past, led to the exploitation of the coastline. Siracusa still remained a very popular tourist destination, but it now had to compete with the economic power of the big holiday camps, owned by foreign entrepreneurs. The result was a period of crisis for local entrepreneurs who were excluded from the market because the services they offered did not meet with demand. Many formerly popular, family-run accommodation facilities, located in the city centre and around Ortigia were obliged to close. The centre of the city lost its ancient vitality and openly showed its social decay in the red light areas and the crumbling architectural heritage.

<sup>1</sup>According to the 1871 survey, Siracusa was the sixth Italian town for number of inhabitants.

The massive exodus from Ortigia in the Sixties continued inexorably for the whole of the Seventies up to the mid-Eighties and particularly involved the eastern side (the Graziella, Sperduta, Giudecca and Maniace) districts morphologically weaker and destitute. The island's inhabitants moved out to the new, modern residential zones along the coastline which were more suitable for modern living requirements.

In Siracusa the degradation of the landscape could be a direct consequence of its economic growth. And maybe the city also had to accept this decay in order to advance. But there is an incredible paradox in all this. If we consider the ancient history of the city, we notice that after the Greek colonization Siracusa experienced a period of great



economic growth and an increase in population, decidedly more notable than that which followed the period of industrialization. But there is nothing in its eloquent ancient ruins to suggest such degradation during that period when the population suddenly increased, reaching a population of more than one million inhabitants, and the city spread.

Contemporary Siracusa has messily grown out of all proportion due to industrialization, but progress has not lived up to expectations, neither has it solved the problems of economic and occupational growth and social improvement. This is evident from the recent economic changes that have taken place, the dominant tendency being towards deindustrialization, together with a continual loss of jobs. The most serious problem is that Siracusa developed within one of the most important archaeological sites in the world. This has made it impracticable to reorganize the town by means of the more usual methods adopted elsewhere, for example by expanding the infrastructure and increasing services. The question of urban recovery is, therefore, really complex to solve. Experts have clearly stated that not only Siracusa and Ortigia, but the whole area compromised by the petrochemical pole (Priolo, Melilli and Augusta) has to be involved in a new economic plan which goes beyond the, by-now unconvincing, solution of industrialization. Subsequently attention has shifted to exploiting the enormous cultural resources of Siracusa, because the real wealth of the city is to be found in its cultural dimension.

### **§ 3 The recovery and re-evaluation of Ortigia**

The worries caused to the local and international community by the profound degradation to the buildings and landscape described above, which saw the death of Siracusa and Ortigia, led to vast recovery and upgrading works of a historical-architectural and landscape-territorial nature within the even vaster community plans for the upgrading and sustainable development of the old town centres known as Community Initiative Programmes, or PIC URBAN. In 120 European Union towns this has led to strategic, integrated actions for economic, cultural and social renovation by means of works aimed at the overall upgrading of degraded, disadvantaged town centre areas. The PIC URBAN has tried to restore vitality, above all to the old town centres, by means of modular, integrated, structured works included in the 5 Measures of the overall Community programme. Most of the works address the problem of promoting and training the local workforce, recovering and improving infrastructures, environmental reclamation and strengthening the social services.

The Siracusa town planners targeted the island of Ortigia, the old town centre, due to the fact that, like many other city centres in the Mediterranean, it has become a peripheral area as evidenced by the great structural and social decay to be found there.

Over a period of more than thirty years the town centre has fallen into a state of urban and social decline.

The programme emphasises some of the most driving aspects of the island:

1. the wealth of its historical, architectural and environmental heritage and its great tourist and cultural potential.
2. its central position in the Mediterranean and its traditional place as a meeting point for different cultures and peoples.
3. its traditional local crafts.

Since 1990 the Town Council has put into effect the Special Plan to salvage the Ortigia town centre (P.P.O.) aimed at upgrading the urban environment and reclaiming buildings in this extraordinary 'palimpsest' of different cultures and architectural styles which testify to the centuries-old history of Siracusa.

Urban was an autonomous, but complementary, working programme to that already put in motion by the local authorities. It aimed at having a strategic, integrative effect on the various key sectors of the island's socio-economic fabric so as to bring about a permanent improvement in the living conditions of its inhabitants, appearing as an effective local political tool.

More specifically, the aim was on the one hand to activate the intrinsic economic and employment potential of the island and, on the other, to respond to some of the population's more important demands, in the first case providing incentives for private investment in the creation of new jobs and in the second carrying out works of immediate benefit to the resident population.

The general objectives of the programme and its connected tools were:

- to deliver the old town centre from its present peripheral condition, promoting its tourist, economic and cultural aspects and reviving the international image of Ortigia by creating new occupations linked to tourism (accommodation and services) and setting up certified sites and services for commercial and craft activities, professional training schools connected to the city's particular crafts (International School for Papyrus Restoration), centres for high-level cultural research and training activities and cultural workshops for the local Ortigia associations and streamlining the traffic system and access to the old town centre using public transport for road (electric minibuses) and sea access.
- to improve environmental conditions and the safety of the inhabitants by taking action in those areas of greatest social risk (petty crime, school drop-out rates, drug addiction, unemployment and isolation) and stimulating participation in community life through services such as activities for children, a youth centre

for meetings, training and practical activities and an old-people's day centre. To carry out social rehabilitation works, improve the general cleanliness and appearance of the centre and install better street lighting which would also exploit the historical-architectural heritage of Ortigia, introduce support and orientation plans to promote and spread an attitude of greater participation and respect for the shared environment and greater safety for residents.

- incentives and support for housing reclamation work and the earthquake-proofing of existing buildings using initiatives aimed at promoting the recovery of buildings as well as a higher quality and supervision of all private and public works. Working through the appropriate local authority departments (the Ortigia local authority cultural wealth and tourism office, the local education authority, the social politics and solidarity office) a special technical assistance structure, included in the five points of the programme, supported the work of the local authority, in line with the methods agreed by the Supervisory Committee. This structure was responsible for the general monitoring of all the works, controlling the procedural mechanisms and checking times and expenses. The works were planned to last from 1995 to 1999. The main results achieved were: the starting up of businesses and a growth in employment which stimulated private investment and small businesses; an increase in the number of services for tourists including alternative accommodation as proven by the opening of numerous shops handling local crafts and typical Sicilian foods as well as an increased number of Bed and Breakfast establishments. Services to residents and general living conditions were also promoted, including safety and there was an overall improvement of the sanitary and environmental conditions of the old town centre. There was a reduction in social unease, which stimulated inhabitants to take an active part in community life and facilitated relations with the local authorities. Professional training and certification took place in some sectors covered by the programme. Residential building reclamation and earthquake-proofing works were carried out and traditional crafts exploited. Finally, the city was promoted internationally by setting up high-level technological and scientific projects.

#### **§ 4 The Urban PIC measures:**

##### Step 1: Setting up of new businesses

In order to increase the number of bed and breakfasts offering accommodation in the old town centre, a syndicate composed of local authority and private resident members was established to provide professional training, consultancy and assistance to those setting up the new businesses and promote suitable advertising in the right sectors.

This step included building reclamation works and services. In particular, the old market was restructured to become a tourist centre. Furthermore, the local authorities tried to increment the facilities for tourists on the island with the building of a solarium (400 sq. m.) near the Fort Vigliena bastion. This proved a great success with both residents and tourists and made it possible to exploit coastline of the island.

As regards the setting up of economic activities on the island and support for local crafts, various businesses were financed and technical assistance provided to local craftsmen to help them study and develop the arts and crafts market through projects which involved the participation of young apprentices in existing workshops. Existing businesses were exploited and promoted and new activities connected with the local culture were set up.

This step had two aims:

- 1) to bring new life to the old town centre and stem the unemployment problem.
- 2) To stimulate the environmental, economic and social upgrading of the old town centre.

##### Step 2: creation and promotion of local jobs

Given that social decline in Ortigia is one of the main problems of the island, a series of measures and social activities were established with the setting up of Centres.

A children's play centre promoted both educational and play activities for younger and older children. These activities were organised in local schools through the creation of special 'animation centres' co-ordinated and managed by qualified personnel financed by the project.

An old people's centre where activities aimed at the local senior citizens were set up with the aim of providing leisure activities, promoting social integration and recovering and transmitting their memories of the past.

Lastly, the youth integration centre aimed at helping disadvantaged young people and promoting their social reintegration. This involved the recovery and reuse of different sites for shows and concerts run by youth groups. These activities aimed at integrating the children and young people of Ortigia by means of a series of activities that would help them acquire the indispensable knowledge and skills to find jobs and thus reduce the poverty of the poorer sections of society, at the same time reducing phenomena such as the school drop-out rate, juvenile crime and drug addiction.

##### Step 3: territorial, social, health and public order services

Step 3 tried to find solutions to the problems inherent in building reclamation works that were also compatible with earthquake-proofing. In particular, the C.N.R. (National Research Centre) studied the facades of the buildings in Ortigia, leading to the definition of two conventions to reduce the seismic vulnerability of Ortigia and a Territorial Information System (S.I.T.) was set up.

#### Step 4: infrastructure and the environment

In addition to the various reconstruction projects aimed at some of the island's important buildings into cultural centres, the main initiative was the creation of a boat link between the island of Ortigia and the mainland so as to reduce traffic congestion.

The expected results are:

1. an overall increase in tourist – cultural facilities and businesses linked to the presence of teachers and students, including foreigners, in Ortigia;
2. the international promotion of Ortigia;
3. a reduction in traffic and air and noise pollution;
4. an increased accessibility of the old town centre and its services;
5. to promote the opening up of new commercial enterprises;
6. the upgrading of the old town centre
7. an improvement in the sanitary conditions and general living conditions of the island;
8. greater public safety due to improved street lighting and upgrading;
9. energy saving measures;
10. the creation of cultural associations and groups to promote cultural growth.

#### Step 5: implementation and publication of the results

An official job advertisement was published to find a person with the right expertise to organise the widespread diffusion and promotion of the objectives, strategies and results of the PIC Urban Siracusa.

In particular, the initiative includes an information leaflet, audiovisual material and advertising of various kinds to inform citizens and operators regarding URBAN and its works.

In conclusion, the experience that the 'Siracusa for Ortigia' URBAN PIC has represented for the local administration and the whole population is one of great growth, not only economic, but also cultural and civil growth, which has returned to Ortigia the dignity of a historical and architectonic heritage and a landscape of universal value.

Ortigia teems with domed palaces and bell-towers in a harmonious riot of styles. Today, the island which measures barely one square kilometre, is a mix of ancient and modern charm. Next to the magnificent ancient remains, new fashionable pubs, lounge bars and wine bars have sprung up, filling the streets of the old town centre at night with the Siracusa 'in-crowd'. Ortigia means entertainment but also art, culture and relaxation. The old town centre is the backdrop and protagonist for innumerable art shows, cultural events, exhibitions, concerts and plays. The 'rebirth' of Ortigia has come about with the same intensity and pathos as the Greek tragedies performed every year in the Greek theatre. The G8 summit organised in Siracusa by Stefania Prestigiacomo, the Environment Minister who originates from the town, led to the opening of many new hotels, bed and breakfasts, restaurants and other.

This is a clear sign that there has been an improvement in the way the cultural and environmental heritage of the island is exploited. Now, young people, residents and tourists can enjoy the extraordinary wealth of the territory, which has been returned to the local community with honours. A modern architecture faculty located in enviable surroundings, is a further attraction to young people who wish to specialise in studies that are relevant to the abundant architectural landscape of the town.

Thanks to the efficient community politics implemented by the internal administration (through a series of offers), the island, and the whole community, is acquiring a new identity and reliving its ancient splendour.

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# METHODOLOGY OF SURVEY AND ASSESSMENT FOR THE CONSERVATION AND RE-USE OF THE ROCCA RANGONI, SPILAMBERTO (ITALY)

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**Keywords:** castle, database, restoration, re-use, survey

## 1. Introduction

The methods of examination and measurement presented here are a selected summary of the research that took place as part of the initial investigation and assessment of the Rocca Rangoni in Spilamberto.

The Rocca, which became public property in 2005, had for almost seven centuries belonged to the powerful Modena family of the Rangoni, becoming identified with the very heart of their fiefdom.

Spilamberto is a small town in North Italy within the region of Modena, once part of the Dukedom of Este. Of medieval origin, it has largely maintained its original layout, even after the demolition of the town walls in the nineteenth century. The Rocca (castle) stood as the fortified point of access to the town on the side towards the river Panaro, which since the Middle Ages had marked the natural boundary between the territories of Modena and Bologna (figure 1).

After it was acquired by the Spilamberto Town Council, what had been the very private residence of the Rangoni family became open to the public. However, there was no ready-made answer as to which approach should be adopted in restoring to the life of the community a complex, age-old building which had long stood almost abandoned and was largely unknown. The town administration tackled the problem by drawing up a programme of specific interdisciplinary investigations and enquiries. After a public competition, the “restoration” section of the project was entrusted to the Department of Architecture and Planning – Restoration Section<sup>1</sup>.

## 2. The surveys

The numerous questions to which we required answers meant that we had to collect and “collate” various kinds of results and analyses. The chosen procedure for the recording of information, which allowed for facts and figures to be seen in relation to each other, was of fundamental importance and meant first that the usual order of investigations preceding a project of restoration and redevelopment was reviewed. The focus was upon direct investigation and examination, with numerous surveys being carried out *on site* which was in part due to the scarcity of bibliographical and archive data that was any real use. As will become clear, in our examination and ‘reading’ of the building, the temporal dimension was a key factor: we did not just focus upon describing the ‘present state’ of the structure, but saw this in relation to the history of the building and the transformations/changes in use it had undergone over the centuries. Thereafter, we could look at the limitations and methods that would come into play when deciding restoration projects and future uses.

The first indispensable step was the topographical and geometrical survey; the main network of the plane level/altimetric framework provides a structure within which are created secondary networks for detailed topographical surveying and on-site surveys. Completed with information from laser scanning and direct on-site surveying, these made it possible to establish the precise size, geometry and complex interior layout of the buildings<sup>2</sup>.

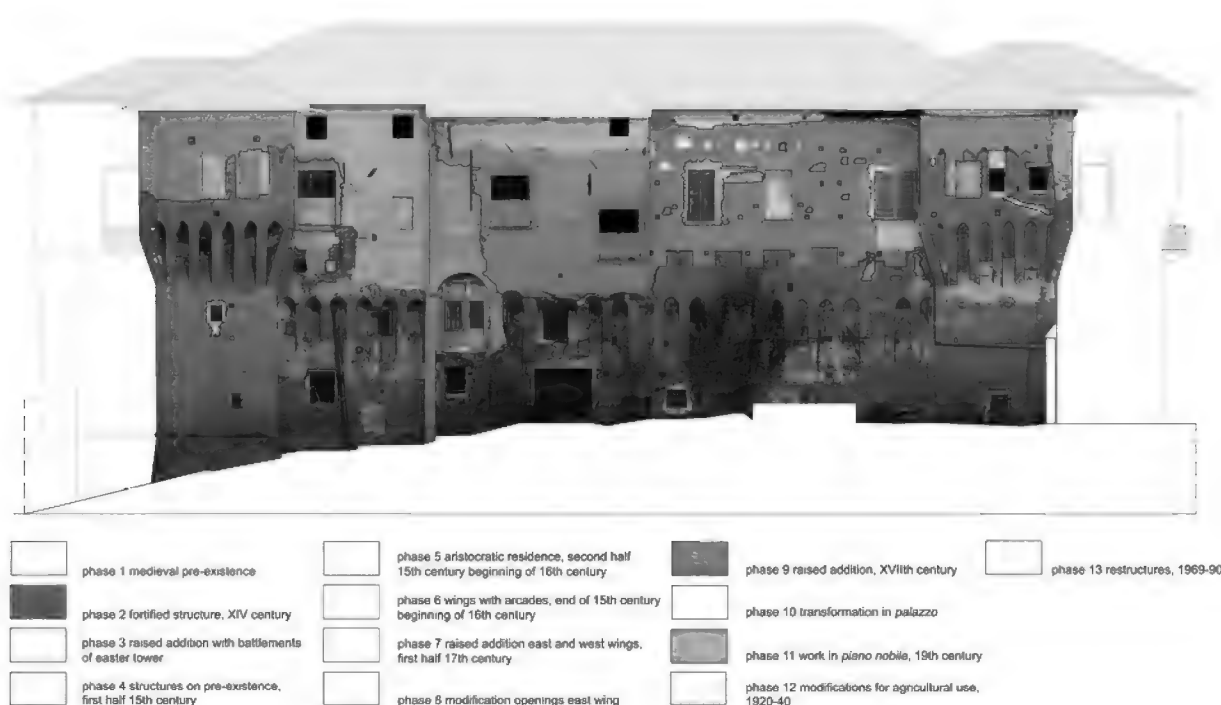
The elevations were rendered through the creation of photoplanes<sup>3</sup>.

The survey highlights the fortified enclosure of the Castle, with its four corner and two central projecting towers. The additions and changes of subsequent centuries produced the layout we know today, modifying the exterior and the interiors of the original quadrilateral. To the south was built the ‘Bailiff’s House’, while to the north was raised a structure intended to serve as a storehouse.





**FIGURE 1.** The Rocca in Spilamberto, south-west sight. Above, one can recognize the fortified enclosure of the Castle, with its four corners and two central projecting towers and the central courtyard. The additions and changes of subsequent centuries produced the layout we know today, modifying the exteriors and the interiors of the original quadrilateral. Below the building constructed in the 18th century as accommodation for the Bailiff.



**FIGURE 2.** Identification of the "macrophases" of the northern façade of the building: the dark grey marks the wall structures that can be dated back to the construction of the fortified castle (its battlements and hound are easily recognisable); in medium grey the raised additions to the façade dating from the transformation into a *palazzo* in the 17th century.

### 3. The database

In order to accumulate a wide spectrum of information, horizontal sections were used as the basis for a framework within which all data could be recorded, thus allowing for a unified and overall (rather than sectorial) reading of the information gathered. Identified with an individual alphanumeric code, each room became part of a database that contains all the information relating to geometrical form, materials, state of conservation and other data concerning changes in use over time.

Given the great number of rooms, two types of information files were prepared, with two types of detailed information.

In the first, the files contains data regarding: the geometry of the room; the materials present and how they were worked; the structure and any cracks boards; the finishings and plasters; the decoration, installations and door and window frames. This information was then compared with stratigraphic reading of the exteriors and the study of indirect sources. The main problems of decay were also studied in relation to the transformations/changes in use that had taken place over time.

These files, which form an open database, can be added to over time, with new information, including those regarding future intervention and project decisions.

The more detailed files covered those rooms and spaces that posed a series of open questions regarding: the time and manner of construction; problems of structural statics; issues regarding the preservation of decorative features. For each surface every feature was catalogued in an individual manner, using a subcode based on the code for the room in question.

The survey covered<sup>4</sup> the finishings, the plasterwork and the painting. Recent recoating with whitewash and industrial paints had covered over the various layers beneath, hence a scalpel was used for stratigraphical examination that often revealed successive layers of plastering, contributing to greater understanding of the development of the building over time.

On the basis of the coordinated data already acquired and the stratigraphical analyses, samples were gathered and submitted for laboratory testing<sup>5</sup>. The results made it possible – *via* comparisons of the binding agents – to distinguish between later medieval paint and plasterwork and that dating from the seventeenth/eighteenth century. They also made possible to identify the results of decay.

Given the absence of archive documentation, the main source of information regarding the building had to be the structure itself. Stratigraphical analysis of the exteriors made it possible to identify the main phases in the building of the Castle. In effect, 14 ‘macrophases’ were distinguished, from the creation of the fortified structure in the fourteenth century, through the work in the seventeenth century to convert the Castle into an aristocratic residence in the 17th century, right up to more recent intervention (figure 2).

Another very important survey that influenced decisions regarding public use of the building involved examination of the wooden ceilings, the data again being collated within the general database. The information files here covered not only the present state of preservation of the ceilings throughout the Castle but also: geometrical form and construction techniques; types of timber and the methods used in working the wood.

Each feature of the structure was recorded in the information files for each single room, which were cross-referenced to the more general database. The resultant overall view of the whole – reflecting considerations of the development of the structure over time, the problems of decay and the issues raised by its re-use – provided a framework for more specifically focused examinations. One such examination involved the use of a resistograph for penetrometrical testing in order to assess the extent and depth of pathologies within the fabric and evaluate the residual sectional resistance of the wooden components .

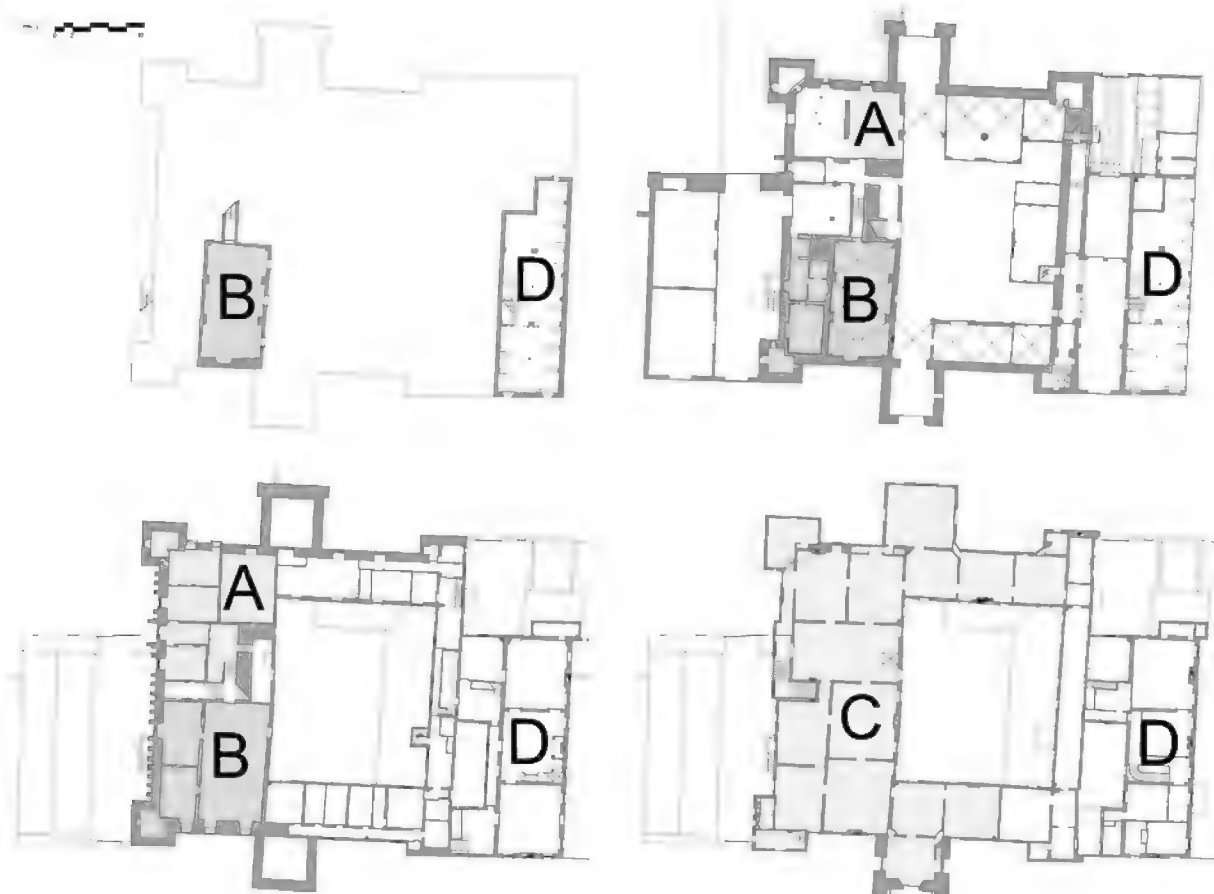
### 4. The new Spilamberto's Museo dell'Aceto Balsamico Tradizionale in the Rocca Rangoni

In 2007 the Town Council suggested that the Rocca Rangoni might become the new Spilamberto's Museo dell'Aceto Balsamico Tradizionale; at present this museum, dedicated to the balsamic vinegar that is a speciality of the Modena area, is housed in a Neoclassical villa to the west of the old town centre. The facilities would include an actual vinegar-works, which contains the barrels in which the vinegar is aged; this process requires specific thermoigrometric conditions, including the wide variations in temperature to be found in the cellars and in the south-facing lofts of the Rocca.



**FIGURE 3.** The monitoring of the microclimate. Distribution of temperature in the longitudinal section. It's possible to see how the vaults over the rooms on the *piano nobile* of the fortified quadrilateral provide a good degree of heat insulation, unlike the lofts of the “Bailiff’s House”, where sizeable variations in temperature were recorded.

**FIGURE 4.** The proposals regarding re-use. Above-left, Basement floor; above-right, Ground floor; below-left, Mezzanine floor; below-right, *Piano nobile*. The 16th-century residence could house the collection of valuable bibliographical and archive materials (A); the old hall for the meetings of the citizenry could become a council chamber (B); the east-north-west area of the *piano nobile* could become exhibition spaces and public reception rooms (C); and the 18th-century Bailiff’s House could be a museum of typical local product (MBTS) (D). The asterisk indicates the most suitable location for lifts.



In order to identify the most suitable location for the Museo dell'Aceto Balsamico Tradizionale – and, more in general, assess possible alternatives for the re-use of the various structures in the Castle – a series of physical parameters were measured; such information we believe to be fundamental in keeping the impact of new installations as limited as possible. For example, thermographic testing not only provided back-up for the stratigraphical analyses but also identified interruptions and empty spaces within the walls and the presence of humidity and evaporation within the external walls. Subsequent gravimetric testing provided a quantitative assessment of the phenomenon.

At the same time, the monitoring<sup>6</sup> of the microclimate was undertaken, over a period from February 2006 to February 2008. This made it possible to: understand the dynamics of thermoigrometric exchange between the structures and their surroundings; identify situations that could undermine the preservation of the structure; and acquire information that was useful in deciding maintenance programmes and how the various spaces should be re-used. As one can see from the image below, it emerged that the vaults over the rooms on the *piano nobile* of the fortified quadrilateral provide a good degree of heat insulation. On the contrary, the lofts of the “Bailiff’s House” – which are south-facing and have no insulation – revealed sizeable variations in temperature (figure 3).

Within the fortified quadrilateral nearly all the rooms of the *piano nobile* are covered by a system of lathwork vaults. Careful studies were made of the construction technology behind the lathwork vaults and of the forms of decay to be found within them. They comprise a structure in wooden ribs to which lath matting is bound by string or copper wire. The intrados surface was then covered by three layers of, predominately gypsum, plaster. These surfaces are decorated with tempera work dating back to different periods. These extensive features are important in understanding the history of the decoration of Rocca Rangoni; they also provide substantial information regarding a building technique that dates back to the seventeenth century. Furthermore, they still afford substantial insulation for these rooms, making them unsuitable to house the vinegar-works.

Unlike the rooms with the lathwork vaults, the lofts of the “Bailiff’s House”, which have undergone sizeable alterations, have no insulation and are south-facing. This makes them a perfect location for the vinegar-works, as the production of vinegar requires substantial variations in temperature.

Carried out when the systematic examination of the ceilings had revealed particular states of decay or inadequacy of beam size<sup>7</sup>, the structural calculations regarding the wooden ceilings in the structure known as the Bailiff’s House showed that – with just some work to consolidate and reinforce – this building can soon be ready for public use, as for the Museo dell'Aceto Balsamico Tradizionale.

## 5. Conclusion: a proposal of re-use

The data collected has resulted in a proposal for re-use which takes into account the fact that, constructed over different periods of time, the various parts of the complex inevitably have different geometric and structural characteristics, with resultant differences in both floor level and elevation. Future types of re-use might involve: the storage of valuable bibliographical and archive material in the sixteenth-century residence (A); the use of the old hall for meetings of the citizenry as a council chamber (B); the installation of a museum dedicated to typical local product in the area of the “Bailiff’s House” (D); and the creation of exhibitions areas and public reception rooms in the east-north-west area of the *piano nobile* (C). The most suitable location for lifts is also proposed (figure 4).

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<sup>1</sup> The Examination Project, Scientific Director: Prof. Carolina Di Biase, Politecnico di Milano, DIAP, Restoration Section. Giulio Azzolini, Barbara Piccinini, Francesca Tinti, final-year undergraduates; Daniela Oreni, Laura Balboni, Paolo Corradini, Juri Badalini, PhD students; Stefania Terenzoni, research-grant holder; Francesca Albani, PhD (stratigraphic analyses); Davide Del Curto, PhD, together with Luca Valisi and Tomaso Cavalli (thermoigrometric analyses, monitoring of weather conditions, inspection and testing of wood structures); Profs Carlo Monti and Raffaella Brumana of the DIIAR, together with Cristiana Achille, Francesco Fassi, Chiara Monti, Daniela Oreni, Federico Prandi, Hande Tuncer and Gabriele Uggeri (topographical surveys and measurements); Cristina Tedeschi, researcher at DIS Material Testing Laboratory (stratigraphic analysis of surfaces); Daniela Penazzi, DIS, (survey and evaluation of structural instabilities); Roberto Bugini, ICVBC-C.N.R. Centro “Gino Bozza” in Milan (sampling and analysis of stone materials); Lorenzo Jurina, professor of Building Technology at DIS (structural testing of the wood ceilings); Gabriele Rinaldi, director of the Lombardy Network of Botanical Gardens (identification of the plants in the Castle grounds).

<sup>2</sup> Using GPS, the main network was georeferenced to the national system of reference (Roma 40). It comprises 11 vertices located around the body of the Castle; from these were taken more than 800 points per level. Together with this there was laser-scanner surveying of the square in front of the Castle and of its external elevations. The instrument used was the Leica HDS3000 total station.

<sup>3</sup> The photoplanes are in a scale of 1:50. Using the topographical points surveyed, the photographs taken of the facades were ‘straightened’ through the application of an analytical method; the mosaics of images were thence formed within sections and elevations determined on the basis of direct topographical and longimetrical measurements.

<sup>4</sup> For each surface every feature was catalogued in an individual manner, using a subcode based on the code for the room in question.

<sup>5</sup> X-ray diffractometry: thin sections observed in polarised light under an optical microscope in order to identify the plasterwork dating from the different phases of construction, and also to identify any results of decay.

<sup>6</sup> 13 thermoigrometric sensors and a psychrometer were used for this monitoring of the microclimate. In the image below, one can see how the vaults over the rooms on the piano nobile of the fortified quadrilateral provide a good degree of heat insulation, unlike the lofts of the “Bailiff’s House”, where sizeable variations in temperature were recorded.

<sup>7</sup> E.g. the examination of the wooden ceiling in Room 249 revealed the presence of ‘recycled’ beams in poplar wood. These had been re-shaped after their previous use and shown signs of twisted wood-fibre.

## SAFEGUARD AND VALORIZATION OF QANATS SITUATED IN THE PROVINCE OF SHAHROOD (IRAN)<sup>1</sup>

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**Summary:** The term qanat commonly refers to ancient underground hydraulic systems for the transport of water in desert areas to satisfy human needs as well as irrigation. In particular in the province of Shahrood (Iran) situated in the northern area of the Kavir desert these underground channels are very frequent and their structure characterize many present and past land settlements. Although qanats are still fully functional because of proper periodical maintenance, in some cases deterioration events take place mostly due to the loss of topographical information. These circumstances mainly occur to qanats composed of many interconnected parts and to the portions which are located further from their outlets. A research project is under way to reconfigure and reconsider sites taking into account functional, cultural and touristic topics.

### *- Geographical overview and geohydrological characteristics*

The province of Shahrood is an extensive territory of the region of Semnan. The latter is situated in eastern Iran, between the northern margin of the Dasht-E-Kavir and the eastern Alborz Mountains. The province of Shahrood is one of the most interesting areas for the study of qanats both for their ancient dating and wide-spreading and for the deep interaction with the local population, in fact qanats still represent an important economy source and water supply. Currently three structures are to be considered among many other units identified: a) Shahrood; b) Beyarjomand; c) Torud.

a) The qanat of Shahrood, integrated by four shafts located at the terminal part and created from the beginning of 1990, is used to supply the city with more than 130.000 inhabitants and satisfies the needs of one third of the population. The hydraulic work develops horizontally for approximately 25 km, with a distance between the highest and lowest points of 385 m and with a 1.5% gradient. It develops roughly parallel to a watercourse with supercritical/ephemeral flow and it is functional over the past 50 years. Of the original hydraulic system only the two upper branches remain, Mojen (3,5 km) and Tash (2 km), because at 4,5 km to their merging downstream the system has been substituted by a modern pipeline in order to preserve the quality and quantity of water adduced. The location of the Shahrood qanat, consists of a degraded flood plain extending from west to south-east. This is bordered by the peaks of Mount Shavar (3945 m) to the north-north west and of Mount Tapal (2815 m) to the south. These peaks are part of the aforementioned Alborz Mountain range. The final section of the plain presents clear evidence of various abandoned qanats, which appear to have been built in different periods to drain water from the eastern and southern buttresses of Mount Tapal and Mount Shahvar respectively. This latter range presents Ordovician schist and sandstone, Silurian basalt, Devonian and Carboniferous schist, sandstone and limestone, Permo Triassic limestone and Eocene volcanic deposits. This is the main groundwater recharge area. In fact, these peaks block the damp currents from the Caspian Sea, promoting precipitation. The Tapal Mountain range consists of Jurassic schist and sandstone, Jurassic-Cretaceous limestone and Eocene limestone and tuff. This area contains clear evidence of karst phenomena and it would appear that this is the main recharge area for the alluvial groundwater used by qanat. The average water flow capacity of this qanat is approximately 120 L/s, the hydrological rate of flow is quite stable during the whole year with  $\pm 10\%$  oscillations. Flow capacity largest values are registered in Spring, the smallest values are registered at the end of January. In the last years a negative trend has been observed in water availability equivalent to 40% decrease of water flow capacity. This showing deficit situation has determined the choice to create 4 shafts to satisfy the increasing summer water needs.

<sup>1</sup> The project study is enacted by an Agreement edited among the Earth Sciences Department of the Technological University of Shahrood, the Environmental Sciences Department of the University of Aquila and the Chemical Methodologies Institute of CNR, Rome. A particular thanks to the Dean of the University of Shahrood, Prof. Ali Moradzadeh, to Dr. Ali Younesian, General Director of the University of Shahrood and to the Eng. Mahmud Matin who has encouraged with his dedication the start up of this project.



*The qanats in the territory of Shahrood (Photo by E. Burri and A. Ferrari)*

b) Beyarjomand qanat is situated approximately at 90 km SE from Shahrood and it is exclusively used for farming activities. It has been built no longer than two centuries ago. The qanat develops for approximately 10 km and it is subdivided in five branches, with a larger gradient than the one that usually characterises this typical underground hydraulic system. This qanat communicates with 190 wells. The primary wells reach depths with a variation ranging from 60 to 120 m and water flow capacity is 40-50 L/s (45 L/s measured on 01/16/2009). Along its route there were 3 watermills, the remains of one of these structures are still well-visible. The peculiar characteristic of this qanat is the presence of two galleries parallel to the two principle branches, which were dug to carry out maintenance functions and 3 barrages to use when necessary to store water and temporarily to interrupt water flow in order to operate maintenance<sup>2</sup>. The chemical and physical parameters obtained during the monitoring campaign in January 2009 highlight a 18,5° C water temperature at the qanat outlet, a 7,9 pH and 800 mS/cm Electrical conductivity (these values are similar to those reported in the descriptive report). First surveys confirm water captation at different temperatures (ranging from 17,4 to 21,3 °C). The qanat develops in conoid, eluvial-colluvial and alluvial deposits which are situated at the base of carbonate and sandstone mountain peaks (Cretaceo-Eocene age) situated at NE. Its branches follow the runoff flows occurring in the plain. The presumable refurbishing area is constituted of detritus deposits and of the near mountain range.



*An ancient mill near Bearjomand (Photo by E. Burri and A. Ferrari)*

<sup>2</sup>The agriculture area that was initially irrigated by this qanat was called Deh Sar Khuche, after a catastrophic flash flood the population moved in a nearby area called Kharab Deh. At last, always owing to calamitous events the population moved in the current area.

c) Torud is a village of 2000 inhabitants, which is situated approximately at 110 km south from Shahrood and lays out in the Kavir desert. The ancient part of the human settlement has been destroyed by an earthquake on 02/12/1953, (a 6.4 magnitude earthquake; epicentre 40 km south from the site) which has caused 970 victims. The outlet of the qanat is inside the village and is used only for shared services as irrigation and lavatory, since water drinking needs take place by means of wells. The qanat should be 8-10 km long, running north to south. In the upper part there are two draining channels, the more western one should have a greater flow capacity. The water flow capacity, measured on 01/17/2009, is approximately 52 L/s at the outlet of the channel. The peculiar characteristic of the water is the high temperature, measuring 24,5°C. The ground water that represents the qanat's main recharge area is located in the eluvial-colluvial deposits of the plain situated north of the human settlement. This ground water is probably furnished by rainwash, by water runoff and by the mountain range percolation of igneous origin located in the northern part of the plain. The presence of lithotypes (Eocene-Oligocene tuff and lava) and important tectonic lineaments can induce water temperature to increase. Marls and sandstones (Oligocenic-Miocenic age), which are disposed widthways to the direction of the drainage plain (NNW-SSE), emerge at south of inhabited Torud, in direction WSW-ENE.



*The oasis of Torud in the Kavir desert (Photo by E. Burri and A. Ferrari)*

#### *Survey on radon gas*

According to present knowledge no studies have been performed on indoor radon in the area concerning Shahrood but the problem of radon in some regions of Iran is meaningful as revealed by the recent monitoring study conducted in the Province of Ramsar (north-west area of Iran) which has highlighted several areas with concentration levels up to 3700 Bq/m<sup>3</sup>. E-Perm electrets with a SST configuration (electret short term installed in a short term chamber) have been used to measure the radon concentration in water. These E-Perm electrets have been put in the chamber for radon in water measurement produced by MI.AM. srl and the results have been read by the SPER-1 Electret's voltage reader previously calibrated and tested.

The results obtained in five radon in water tests performed are reported below.

- Shahrood qanat: water sample was collected at the end of the underground pipeline which connects the former qanat to the city. Radon Concentration = 5,79 Bq/l
- Beyarjomand qanat: water sample was collected from one of the shafts of the qanat branch running parallel to the main road entering the village. Radon Concentration = 9,49 Bq/l
- Beyarjomand qanat: water sample was collected from one of the shafts of one of the two branches (water temperature aprox. 22° C) flowing into the perpendicular branch to the main road entering in the village. Radon Concentration = 13,69 Bq/l



- Torud qanat – water sample was collected at the end of the qanat course, when it arises in a construction situated under a funeral monument. Radon Concentration = 0,96 Bq/l (data given by the average of the two values found, as the measurement was taken double)

These first results obtained from the monitoring campaign carried out in January 2009 are really encouraging, as the values are largely inferior to the World average and the concentration of radioactivity in water does not represent any hazard for the population. In particular the qanat value obtained in Shahrood is very comforting as the water of that qanat provides people's houses with drinking water.

#### *Valorization and safeguard related to Cultural Heritage<sup>3</sup>*

The study of qanats in northeastern Iran has gone beyond their hydrogeological and physical characteristics. In fact their configuration allowed human settlement and influenced social rules, cultural activities and the economy of water agriculture exploitation, through a tight relationship between mankind and environment. The interest in this precious subterranean aqueduct is still alive and topical and this is highlighted by a complex and continuous maintenance activity which make qanats reliable and long-lasting. This upkeep activity, onerous and often hazardous, is aimed to re-enable underground pipes, but does not take into account the historical complexity of social and economic relationships and the value of accessory works. These additional features loose their function besides presenting structural deterioration.

The research investigation starts with a general, topographical and structural reconnaissance of manufactures even with the collaboration of those who contributed to their functional restoration. At the end of this phase, the further steps were to locate the exact positions of the shafts by GPS, to prepare the photographic documentation and to fill out a form which also includes additional features. The next phase is the survey of artifacts still existent such as mills which receive their motive power from the underground channel system. All this information is completed by accomplishing dating tests on the artifacts. So a proper radiography of the qanat is obtained, with the aim to introduce it in a diversified and complex cultural circuit for a complete valorization of the area, of its handicraft and traditional agriculture.



*The caravanserai of Miandash along the silk road (Photo by E. Burri and A. Ferrari)*

<sup>3</sup>Samples have been taken from small pieces of pottery, encompassed in the walls of Beyarjomand mill's ruins, in order to attempt a chronological dating test. The relics are to be referred to terra-cotta fragments, which date in the VII century AD, precisely 680+/-80 AD. Obviously the date refers to the last heating at high temperature of the ceramic fragments which

*coincides with the ceramic workmanship, but not with the make-ready of the fragments into the mill structure. The radiocarbon analyses of straw and wood fragments provide much more recent dating, that is later than 1650 AD; straw and wood fragments are related to when they have been inserted into the structure. The site is characterised by a considerable aridity, anyhow there are rainfalls which will have required periodic interventions of consolidation. Therefore it is possible to assume that the fragments of straw and wood are non contemporary to the first production of the artefact but are due to following interventions. Other cross sections and analyses have been carried out in the Miandash caravansary, which is supplied by a net of qanats. In this case dating methodologies through thermoluminescence technique are more secure because the bricks analysed do not give rise to reuse hypotheses. The results of the analyses relating to four points of drawing concur among each other and give as a dating result 1655  $\pm$  30 AD. It has been possible to draw samples only from the external structure of the big caravansary, later dated structure compared to the main body. The analyses, conducted on December 2009, have been accomplished by Prof. Marco Martini, Director of the Department of Materials Science, University Milano-Bicocca, Italy.*

On the basis of this program it has been possible to identify some solutions for the following three sites:

#### *Shahrood qanats*

This hydraulic system is composed by a thick net of ancient, old and quite recent qanats and it expands almost till Mojen town. This irrigation system is of vital importance because 30% of domestic water use of Shahrood city comes from these qanats. The whole city is surrounded by the qanat water through densely cobwebbing channels that run along the main streets which are shaded by a row of trees reminding the vital nexus which binds its existence to the essential presence of the qanat. Shahrood, by means of its accommodation facilities is definitely equipped to function as a base and reference point for several cultural routes in order to be acquainted with the qanats of the province and the landscape.

Particular attention will be directed to the topographical survey of a thick qanat net located in the northern area of the city and proved only by the great quantity of abandoned shafts which have been filled with dirt. A fortified structure, which totally lapsed and others that are still partially in use, today prove an economy based even on trade.

#### *Byāryomand qanat*

This small town of about 2.300 inhabitants represents the final connection with the area of Shahrood before advancing into the Dasht-e-Kavir desert. The qanat which supplies it with water has two main branches with a peculiar characteristic, one of the two branches brings quite hot water, even in Winter.

The whole qanat area is surrounded by high mountains and Byāryomand landscape is favourable to create an open air qanat route-museum. For this purpose one of the ancient watermills could be restored. In the past it was activated by the qanat water which was collected in expansion chambers in order to allow the movement of the grinding gear of the mill.

During qanats maintenance and cleaning operations accomplished by Afghan workers, blocks of calcite have been removed from some shafts, over 100 m deep, and brought on the surface. These blocks were obstructing the underground tunnels. With a low investment it would be possible to start an interesting hand-crafted activity to create tourist art objects and furnishings which could be put side by side with the other local activities.

#### *Torud qanat*

This oasis settlement is situated to the south of Shahrood and lays out in the Dasht-e-Kavir full desert, a little before the great Kavir salt lands. Here the meager population, approximately 2.000 inhabitants, stands severe thermal excursions and is almost totally committed to agriculture, although it could improve its economic conditions by increasing the value of cultural assets tightly connected to the presence of the qanat.

First of all the qanat water spouts near the midtown, from where the water is directly distributed to the farmers through a very thick net of small channels which guarantee the necessary agriculture activity. This ancient water supply system for desert areas could be successfully considered within a cultural tourism by tracing itineraries that show the culture of water use in arid environments, the processing and conservation techniques of manufactures and the gastronomic culture. Lastly the tourist itinerary could comprise a carpet marketing inspired to local culture patterns, with methodologies, techniques, hand-woven textile fabrics and colors handed down through many generations.

The water analysis of the Torud qanat was approximately 24,5° C temperature, measured in January while the external temperature was approximately 0°C. An accurate study on this phenomenon would allow a careful evaluation for a thermal and/or geothermal exploitation at low heat content.



*The qanats in the territory of Shahrood (Photo by E. Burri and A. Ferrari)*

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## A VALORIZATION PROPOSAL FOR THE CITY OF MALVAGNA (SICILY) THROUGH THE CONSTRUCTION OF AN ENERGETIC ISLAND AND A DIFFUSE HOTEL

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1. Recently we've assisted to the possibility to carry out some initiatives that aim at increasing the value of territory, the safeguard of characteristics of a local cultural patrimony.

These initiatives are strongly related to the sustainable paradigm, that since eighty's, has been asserted as the most important topic for all those policies or ideas about development. A proposal of territory valorization, in order to proceed and act at a local level for echo-oriented sustainable development, born in the town of Malvagna through the construction of an **Energetic Island** and **City Hotel**.

The aim of the project represents, therefore, a voluntary action of construction and sharing of a future vision of a territory, objectives and strategies in order to achieve them thanks to public and private interventions: to construct an identity of the territory.

Moreover, this formula will represent an important opportunity for all these territories, communities that, like Malvagna, suffer particular factors of depopulation, marginality, abandonment, as well as lack of initiatives of territory valorization. To better understand this initiative, that is currently in progress in this little Sicilian reality, it is useful to contextualize the situation of Malvagna, analyzing not only the demographic trend of population, but also its territory and the potentialities that can offer.

Malvagna is a little town, located in the Sicilian hinterland at about 710 m above sea level; its surface is about of 7 square km, and its inhabitants, called "Malvagnesi", are about 900. Malvagna has a strategic position because it is located close to the big Sicilian parks: Etna's park and Nebrodi's one. The presence of these two parks is an important resource in a prospective of territory recovery because it might foment the naturalistic and rural tourism.

Moreover Malvagna is not very far from Taormina or Giardini, two very famous Sicilian seaside localities.

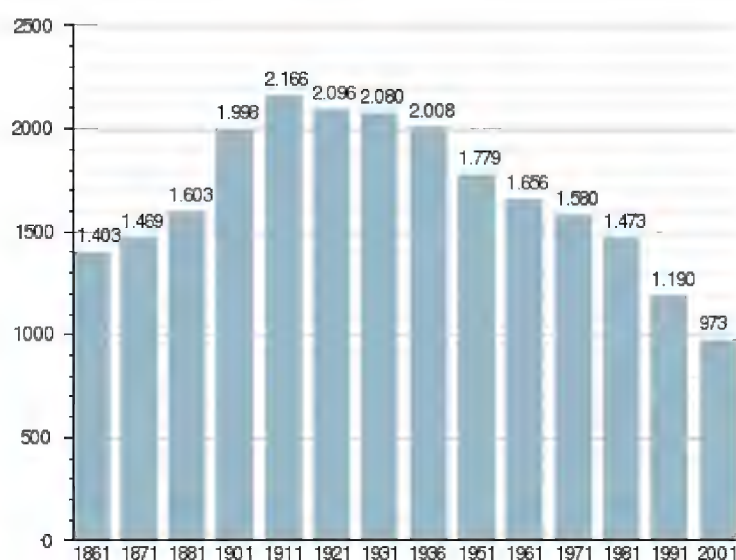
It has to be mention the presence of the Malabotta Wood very close to Malvagna. It is located at the north side of Malvagna, and it can be considered an important natural element because it makes Malvagna as "a natural corridor" for wine routes, itineraries to reach Etna and its winter plants.



Figure 1

Unfortunately, as already said before, Malvagna is one of those little towns that suffer a progressive and increasing situation of depopulation caused by the abandonment of lands. Moreover a population no more made up of young people causes a lack of specialized workforce.





fonte ISTAT - elaborazione grafica a cura di Wikipedia

**Figure II - Demographic evolution Census inhabitants - Source: ISTAT.**

This graph shows clearly the terrible trend of the demographic evolution and how much the population is decreasing over the past years. According to this census, in 2001, Malvagna presented a population of just 973 people. This phenomenon involves many communities present in the Sicilian hinterland with less than 3000 inhabitants, especially those ones far away from the big cities.

OSSERVATORIO STATISTICO SULLE DINAMICHE SOCIO-ECONOMICHE E TERRITORIALI DEI COMUNI MONTANI

Ufficio Speciale della Montagna

Dipartimento Regionale Urbanistica: U.O. 2.1 - Statistiche territoriali

TAVOLA DELLO SPOPOLAMENTO MONTANO

*Comuni montani in forte spopolamento (n° 14)*

N° d'ord.	classi dem.	Prov.	Comune	INTENSITA' DI SPOPOLAMENTO	Valore, % pop. 71-2004	Variaz. ass. pop. 71-2004	1971	1981	1991	2001	2004	Trend (vari. da popolazione 2001)
1	fino a 3000	ME	Fondachelli-Fantina	FORTISSIMO	-57,9	-1610	2779	1921	1643	1235	1169	T
2	fino a 3000	ME	Casalvecchio Siculo		-53,3	-1225	2299	1702	1447	1152	1074	T
3	fino a 3000	ME	Raccuja		-52,3	-1421	2716	2296	1692	1389	1295	T
4	fino a 3000	ME	Ucria		-50,9	-1312	2576	1857	1646	1370	1264	P
5	fino a 3000	ME	Novara di Sicilia	FORTE	-47,5	-1453	3659	3039	2197	1731	1606	T
6	fino a 3000	ME	Roccella Valdemone		-46,2	-690	1492	1325	990	841	802	T
7	fino a 3000	ME	Mongiuflì Melia		-43,3	-567	1310	1125	975	783	743	T
8	fino a 3000	ME	Malvagna		-43,1	-681	1580	1473	1190	973	899	T
9	fino a 3000	ME	San Salvatore di Fitalia		-43,0	-1185	2758	2196	1954	1679	1573	P
10	fino a 3000	CL	Resuttano		-42,9	-1781	4151	3219	2752	2467	2370	T
11	fino a 3000	ME	Tripi		-42,5	-744	1752	1394	1225	1044	1008	P
12	fino a 3000	PA	Bompietro		-41,6	-1170	2810	2381	2055	1754	1640	T
13	fino a 3000	ME	Floresta		-40,5	-404	998	1035	923	637	594	T
14	fino a 3000	PA	San Mauro Castelverde		-40,2	-1351	3434	3151	2565	2166	2053	T

**Figure III - Table of mountain depopulation (Source: Osservatorio statistico sulle dinamiche socio-economiche e territoriali dei comuni montani, from "Montanità ed insularità nella pianificazione della politica europea", R. Interlandi.)**

This graph shows the mountain villages in Sicily that suffer of this phenomenon of depopulation. Malvagna is the 8<sup>th</sup> town in this table, and during the period between 1971 and 2004 faced a decrease of 43,1% of population.

Keeping this trend, the town risks a total extinction in 2044. This year has been indicated by analysis conducted on demographic trends as the year when there will be no hope to invert the negative performances registered over the past 30 years.

What is illustrated is not just a catastrophic opinion, but represents the reality. This place, like many others, suffers this depopulation especially by young people, derived by the lack of potential employment, and this phenomenon is probably the most difficult one to be arrested. Only a synergic action that involves all the stakeholders, services, everything related to the environmental tourism, able to invert this negative and regressive trends, could stop this exodus by mountains.

A proposal valorization for the city of Malvagna, through the construction of an energetic island and a diffuse hotel, born by the need to carry out effective measures that will be able to valorize the endogenous resources in a sustainable and wise way, and at the same time that will be able to create employment, as much as possible, for people living there, above all young people.

This initiative proposes the constitution of a **Urban Transformation Society** (S.T.U.) for the city of Malvagna, finalized to realize interventions such as :

- Self-sufficient Energy
- Zero-emission City
- 100% garbage disposal
- Hotel city
- Malvagna as “natural commercial centre”

If these interventions will be realized, the city hall will be able to arrest this phenomenon of depopulation and the abandonment of this important socio-cultural patrimony, constituting, at the same time, a factor of development for all the surrounding zones that, thanks to the rebirth of Malvagna, will receive an increased interest.

Obviously these initiatives have to be concretized according a sustainable prospective and considering the consequent environmental impact.

2. The initiative will consider, as interventions areas these three place:

1. Old garbage dump
2. Malabotta wood
3. Old town

Concerning the old garbage dump, it is a zone very interesting because a “land reclamation” has already started. This old garbage dump constitutes the driving force for the project of an “energetic island”: it’s here in fact where it is possible to build the **alternative energy systems**, and this area is adapted as well to take **a permanent research laboratory** and **experimentation centre of new urban balances**.

Basically it concerns to a new model of territory organization, with the aim to substitute the typical forms of energy supply (those one from polluting electric systems) with plants powered by renewable sources with an extremely low environmental impact.

Thanks to this project, Malvagna and other little communities will have the opportunity to come off the traditional electric net to become “energetic islands” and produce by themselves the necessary energy through the use of renewable resources present in the territory (solar energy, Aeolian energy, etc).

These new “plants” will have to be realized in order to satisfy the energetic request keeping the current welfare standards and, at the same time, reducing carbon dioxide emissions from fossil fuels and the consequent environmental impact. Moreover this order will lead to a definition and realization of a new model of eco-oriented urban expansion that will be subsequently applied also to the industrial agglomerates with significant consequent reduction of pollutants.

**“Saving Energy costs less then producing it”** : this sentence summarizes the essential idea behind the propose of an “Energetic Island”.

It is necessary to follow a choose that tends to raise the energetic efficiency starting right from the structure of buildings, through a program of requalification and reorganization of the old patrimony and through a realization of new buildings that will foresee a minimum annual energy need.

For these reasons the initiative foresees to create a building agglomerate, planned with the most recent **bioclimatic technologic architectures**, using “clean” sources.

This agglomerate will be made up of buildings equipped by an electric production system (thermodynamic solar and endothermic system) that will make possible the totality self-sufficiency 24 hours a day, and it will guarantee an exceptional energetic saving, reducing at the same time drastically the pollutant emissions that cause the current climatic problems until their complete disappear.

Therefore this project aims at guaranteeing the energetic self-sufficiency through a territorial and cultural approach finalized to the revalorization of the places existential patrimony and through a rebirth of the local economy.

About The Malabotta wood, the initiative considers just the 434 hectares concerning Malvagna. It is about the 15 % of the total surface of the wood (the totality surface of this wood is about 3221 hectares). Malvagna wood, one of

the few survived forests in Sicily, is located close to the Nebrodi park and it is an incredible green lung that presents an exceptional value in terms of ecological diversity. The wood, part of protected areas in Sicily, thanks to its naturalistic attractions, offers the opportunity to graft an hiking tourism.

Considering the last aspect of this project, the idea of a “diffuse hotel”, the initiative foresees to promote in Malvagna, the constitution of a consortium reuniting the owners of those crumbling houses and encourage them to restructure these houses by now uninhabited. The idea proposed is to transform, through a synergic sharing by all people involved in this situation, the urban existing agglomerate in a hotel village through a process of recovery and restructuring.

The diffuse hotel is a formula particularly adapted to those villages that, like Malvagna, are characterized by old town with an important artistic and architectonic interest. In this way these villages can recover, revalue these old buildings and at the same time resolve the receptive touristic problems without building new structures.

The diffuse hotels are not B&B or agritourisms, but they are much more a form of “horizontal” receptiveness because they allow tourists to live much more in contact with people living there. Farms, houses, noble buildings equipped of every comfort and reception are located in the old town and in this way tourists are in contact with its resources: jobs, arts, tastes, events.

The diffuse hotel allows tourists to live his holiday in proper houses, with many aspects, such as walls, spaces, furnishings, completely different of those ones designed commonly for tourists.

There are already some European countries where the public institutions have carried forward similar initiatives in order to encourage the development of poor areas.

For example the “paradores” in Spain; they are a sort of luxurious hotels, but they are managed by the state: usually they are old buildings, converted in real hotels and usually located in rural zones.

The “pousadas” in Portugal or the “gites de France” in France are another examples of this kind of approach. All these examples are associated by the same need: to retrain historic buildings that have suitable characteristics to a high standard receptivity.

In Italy, the idea of a “diffuse hotel” took form during the 90’s above all in those regions with autonomous statute, or in the south part of Italy where the prices of houses are still low.

In this moment the Diffuse hotels in Italy are 54 and they are located above all in Sardegna, Puglia, Molise, Friuli.

**Figure IV - Diffuse hotel in Italy 2007. Total 54 (Source: Tg1 Economia, edition 31/08/2007)**

Abruzzo	2
Basilicata	3
Calabria	4
Campania	3
Emilia Romagna	2
Friuli	7
Lazio	1
Marche	4
Molise	8
Piemonte	0
Puglia	8
Sardegna	5
Sicilia	2
Toscana	3
Umbria	2

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# SUSTAINABLE TECHNOLOGIES FOR DIAGNOSTIC ANALYSIS AND RESTORATION TECHNIQUES: THE CHALLENGE OF THE “GREEN CONSERVATION”.

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## Abstract

The European guidelines for the future of our society has set, as key objectives, to become a knowledge-based economy, capable to develop a high level of entrepreneurial ability, innovation and research. Within the cultural Heritage circle these three topics, deeply connected, are not sufficiently faced up in an integrated way. In the restoration sector, that in Italy involves a huge amount of historical buildings with incomparable artistic value, a heated debate over methodological issues is carried on, but solutions on the themes of social and economic sustainability of the conservation interventions are missing. These themes regard all Europe and interlace with the capacity of developing new solutions for improving energy efficiency of historic buildings through renovation, as well as adapting new and modern technologies to the requirements and special problems associated with historic buildings and energy efficiency. In the field of plants and energy saving, scientific and industrial research produce high performance solutions, that not always are able to guarantee the respect of the integrity and authenticity of monuments, as well as their sustainability, comfort and ‘livability’. This paper will show the green conservation methodology, an approach aimed to develop guidelines and a design model for carrying out energy efficient renovation measures in historic buildings with regard to compatibility, sustainability and quality of life improvements. The analyzing strategy is demonstrated by using as case study the castle of Zena, near Piacenza, Italy.

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**Keywords:** Green conservation; Historical buildings; Sustainability; Castle architecture; Energy efficient renovation.

## 1. Introduction

The theme of sustainability of Cultural Heritage is today particularly focused on the preservation of historical buildings. For this aim the attention have to be taken to the impacts and how they ramify on the survival and safeguarding of the historical edifice. Many projects and research are developed about buildings and their emissions as a cause of environmental impacts, and about stewardship strategies deployed to control them [1]. But the reverse is true as well. Our monuments are constantly bearing the brunt of the environment’s charge, be it due to climate change or to calamities such as earthquakes, volcanoes and hurricanes. Heading the list are impacts driven by humans, who use these buildings, and whose wars and vandalism often destroy them. Ill-considered conservation intervention can also give rise to serious impacts on the very heritage we want to safeguard. Several reinforced concrete structures produced a few decades ago to bolster historical buildings built of stone, which collapsed in ruins on being shaken by quakes, as was the case recently in Abruzzo. New-tech but incompatible with pre-existing, these objects failed in their purpose, with catastrophic, destructive effects (Fig. 1, 2).

In heritage preservation, sustainability means holding onto and handing down cultural treasure, and stopping or mitigating the harmful impacts that threaten it. It is therefore necessary to talk about the concept of sustainability not merely addressing the themes of energy efficiency and savings for the environment. A wider perspective is needed in order to apply sustainability to the entire complex process that starts up when we decide to restore an historical building. We must ask if it is sustainable from the very outset, when we plan the point to be reached, and in the subsequent phase when we study its state of preservation, and all along the line. When we formulate our project proposal.

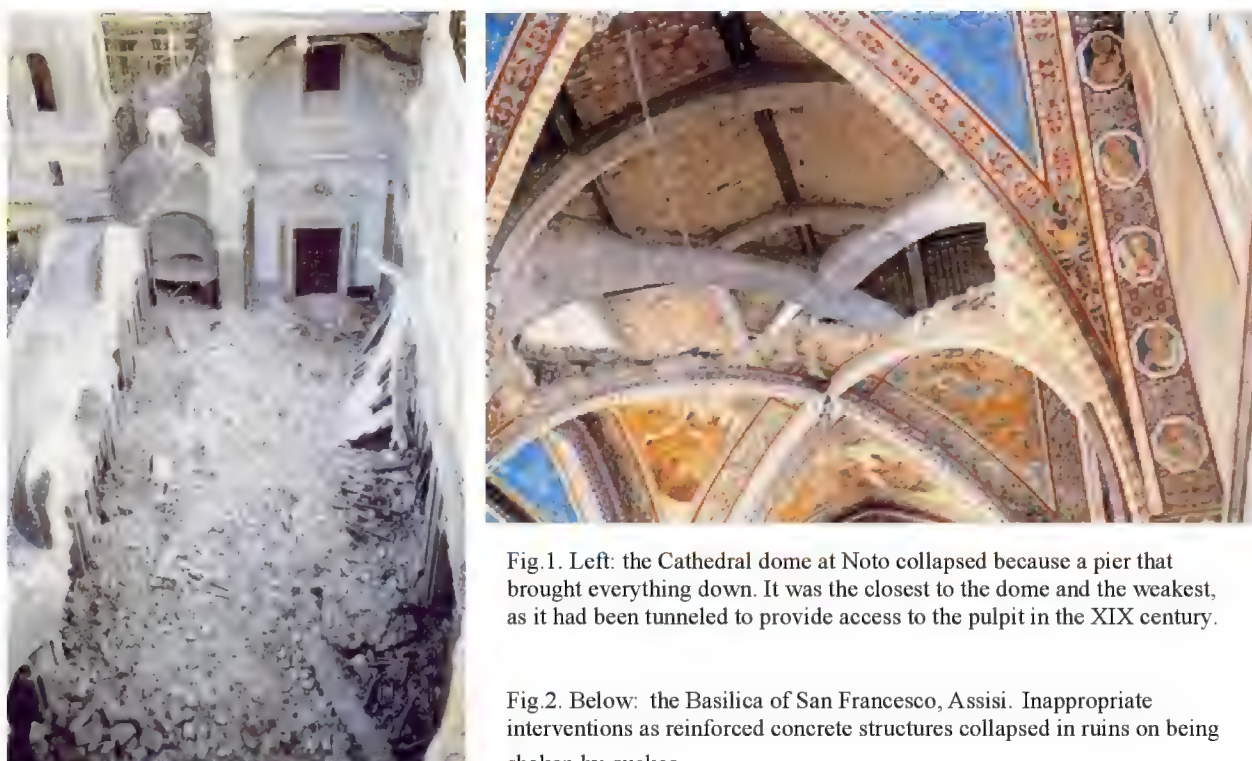


Fig.1. Left: the Cathedral dome at Noto collapsed because a pier that brought everything down. It was the closest to the dome and the weakest, as it had been tunneled to provide access to the pulpit in the XIX century.

Fig.2. Below: the Basilica of San Francesco, Assisi. Inappropriate interventions as reinforced concrete structures collapsed in ruins on being shaken by quakes

When we choose methods, techniques, materials and technologies to deploy. When we prepare the maintenance schedule to accompany the building over time. The link between preservation and sustainability is based on the principle that rescuing historical buildings is not achieved only via projects and technology, but begins with examination of environmental problem areas, squares them with resources of available space, materials and energy supply, but also casts an eye on economic macro-trends, social institutions and cultural underpinnings. The key word for the future of monuments shall be “*sustainable restoration*”.

Traveling back to the original concept of sustainable development, as set out in the early 90s in Agenda 21, we see that it is based on multiple factors. The environment occupies one of four right angles of a square, with the economy, social sphere and cultural sphere in the others. Extrapolate these multiple factors to the concept of “sustainable restoration”, we obtain a quadrilateral that displays energy & environment at one right angle. The others are occupied by science & technology, socio-economic concerns and cultural concerns (Fig.3).



Fig.3. Relations among factors for sustainable restoration.



Fig.4. Relations among factors for sustainable restoration.

On the basis of these factors, it is possible to establish four key premises:

1. Sustainable restoration is contingent on the cultural approach we take towards the preservation of historical buildings
2. Diagnostic inquiry and technological solutions must follow a holistic approach
3. Intervention shall be based on coupling traditional technology and innovative technology



4. Preservation decision-making must make use of manifold criteria to guarantee airtime for the opinions of all key actors.

The cultural approach that guides preservation decision-making is conditioned by notions of preservation, and by the theories and methodologies that every restorer follows.



Fig.5. Zena castle east façade. State of conservation thematic map.

## 2. Sustainable technologies for diagnostic analysis and restoration techniques

To intervene we need to find out about the building we are restoring. Such action is performed via diagnosis, or rather through the interpretation of instances of decay and damage. But it doesn't always go that way, due to reasons of cost, or belief that naked-eye assessments and intuition are enough to say what the damage is. We have to dump the compartmentalization of capabilities that has characterized the development of western culture, which leads to the isolating of fields of knowledge, one from the other, thereby reducing chances of useful interaction that are gained through the mingling of disciplines, whether humanistic or hard science. The aim is to favor a holistic approach to knowledge of cultural property: buildings must be seen as a complex system of functions and interrelated components (Fig.4).

Best results are achieved through projects that exploit synergies of actors, sciences and knowledge bases working in concert: archaeology, architecture, chemistry, physics and engineering, as well as sociology, economics and planning [2]. Their input can be of benefit as we move along the fact-finding how-to-do path shown by the analysis of the construction. The method in question retraces the entire sequence, from historical study to the validation of geometrics, materials and technology of the architecture, from interpretation of construction "pathologies" right own to the recording of environmental stresses, so as to delineate project strategies that will take policies of historical preservation and urban planning into account [3].

It is difficult to guarantee the sustainability of the restoration because we have to choose materials and techniques in this era, when technology is drifting away from science, as it responds to market demand, often acting as the pointer for our economic strategies. Likewise in the construction sector, technological research and industrial production offer products of excellence that are constantly advancing, whose results, however, when applied to monuments, do not always manage to satisfy criteria of compatibility with what exists, minimum intervention and reversibility. Our proposal is to orient technological choices towards integration of traditional and innovative techniques. We don't just need to recoup original building materials and local methods of construction, but we must also migrate performance characteristics of the old products to the new ones, likewise the operating philosophy. Study of traditional knowledge must be an instrument of support for compatible conception and upgrading present in modern-day production innovation.

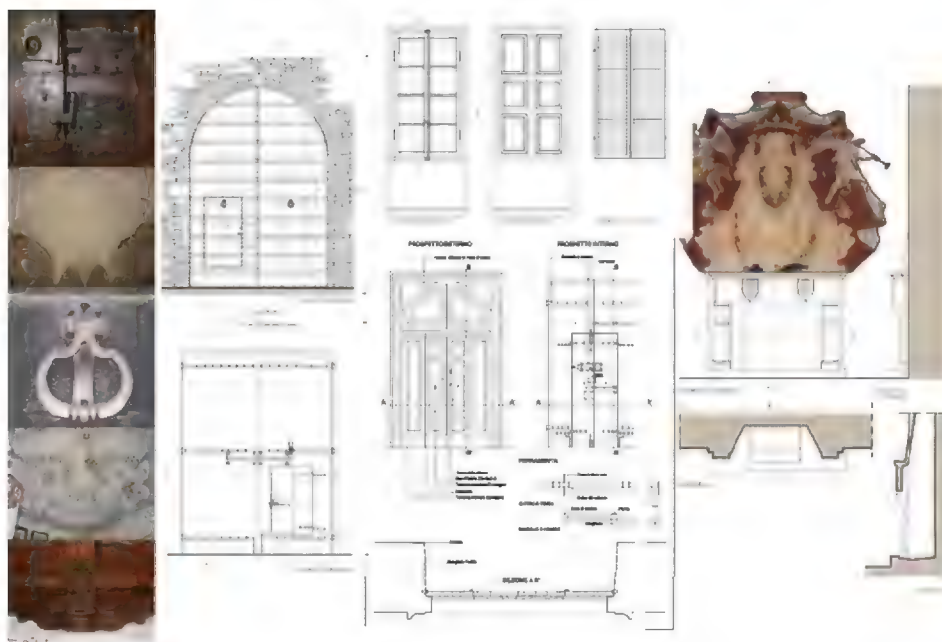


Fig.6. Zena castle. Survey and documentation of architectural components related to energy efficiency. Doors, windows and chimneys.

### 3. Green Conservation.

Through the Built Heritage Lab (BHLab) of the Institute for Technologies Applied to Cultural Heritage (ITABC), CNR (the National Research Council) has launched a research sector to develop the concept of *Green Conservation* ©. This approach to the theme of conservation was created to respond to the difficult task of defending the existing in the delicate balance between past and present, to reconcile tradition and innovation, historical elements and contemporary findings, as well as multicultural languages and technological expressions. Above all, the idea of green conservation must be viewed as a scientific and operational method for answering and overcoming the challenges of energetic and environmental sustainability in the constructed heritage, through an innovative approach to historical restoration.

Currently BHLab has two research projects underway on this theme - one at a national level and another at a European level. The first project SOCRATES (Operating System for Coordinated Research on the Technological Retrofitting of Historic Buildings) began in 2005 and it is promoted and financed by the VIVECA company in Piacenza, with scientific coordination by ITABC (Institute for Technologies Applied to Cultural Heritage). It was developed in collaboration with several University departments including the Land, Environment and Geo-Engineering Department (DITAG) and Soluzioni Innovative per il Rilevamento (SIR) at the Polytechnic University of Turin; the Archaeology Department at the University of Bologna; the Department of Physics and Chemistry of the Earth (CFTA) at the University of Palermo and the Diasis spin-off; the Energy Department at the Polytechnic University of Milan and with the CNR's Institute for Archaeological and Monumental Heritage (IBAM) and Institute of Science and Technology for Ceramics (ISTEC) [4].

The green conservation method emphasises a 'holistic' approach to understanding the building which is viewed as a complex system of integrated functions and components. The holistic approach also extends to technological research with the idea of integrating traditional and innovative technologies. The goal is above all aimed at transferring the performance characteristics and operating philosophies of traditional methods to new products in order to support the development of and compatible improvements in current manufacturing innovations, to find solutions that suit monumental constructions. Technologies are sustainable if they optimise systems, materials and tools that are already available from research, to diagnose, monitor and plan initiatives for conservation. The objective is to improve the quality of safeguarding processes and make costs more sustainable over the long term with innovative applications that also lower the environmental impact of interventions (ecological materials, emissions control, and energetic performance). These processes also relate to innovative non invasive methods for analysing, documenting and monitoring with special reference to sustainable imaging diagnostics.

### 4. The case study of Zena castle and sustainable technologies

The Zena Castle research and project represented a fundamental occasion for trying out, applying and diffusing this "green" vision of architectural restoration that is articulated over several stages. The first stage dealt with the status of the technological research, followed by a stage aimed at understanding the monument. The objective was to acquire elements of data and documentation on the historical, construction and artistic aspects of the structure in



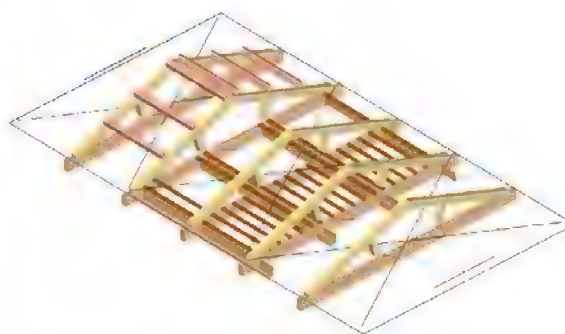
order to understand its evolution, improve its usability and highlight the structure while supervising the sustainability of all of the works to be carried out.

The construction sector, and as a consequence the restoration of constructed heritage, are part of the new technological *ET (Energy Technology)* sector that imperiously pairs with the *IT (Information Technology)* sector which has dominated the scientific and industrial panorama of the past twenty years. With the establishment of a scientific path, the frontier of restoration has become “green” and it is moving towards the concept of green conservation, which is a theoretical, methodological and technological approach that uses innovative principles to design interventions of conservation and functional restoration for buildings with significant historical and architectural value. This path represents an essential guide for performing restoration that is compatible with the contemporary need to reuse this heritage. Above all it tends to establish a design and performance method that is a “model for technologically sustainable intervention”. This research overcomes the challenge of providing efficient alternative energy for historic buildings without compromising their protection also through systematic monitoring of extreme deterioration caused by the environment in order to study methods for preventing and counteracting it. The state of conservation was assessed through actions of architectural analysis and diagnostic enquiry integrated with historical data [5]. This was carried out by surveying varying aspects and analysing the materials (Fig. 5). A careful survey was made of all of the architectural finishing components such as the external and internal windows and door frames in order to study these elements which are important both from a figurative and technological standpoint, and develop procedures for their conservation and functional integration (Fig. 6). The general survey allowed for highlighting and cataloguing the techniques used to build the vertical and horizontal structures and therefore, for highlighting the construction characteristics of the walls, floors and ceilings, as well as the structure of the roof (Fig. 7).

At the same time, a study was carried out on the system design criteria, problematic issues, and the specific techniques and regulations to be followed in order to employ renewable energy solutions for saving energy. This process did not necessarily aim to delve into new technological discoveries, but it was aimed at optimising skills, products and solutions that are able to combat the energetic inefficiency of historical buildings. Photovoltaic technology, for example, was considered as not being suited for the roof of the castle, but it was used in a few of the surrounding agricultural buildings. The research is currently aimed at possibly using thin-film photovoltaics. These innovative extremely slim products can be applied to roofs, mortar and windows, without the size and aesthetic impact of solar cells that are currently available on the market.



Fig.7. Zena castle. Sustainable solutions for consolidation and retrofitting works, on the roof and at the south-east front.



In relation to materials, the challenge involves being able to supply traditional materials such as mortar and paint that provide better insulation without penalising transpiration or compromising the capillary flow, while guaranteeing maintenance-free surfaces, as already takes place currently with titanium dioxide additives for the exterior walls of modern buildings. The same goes for materials such as insulation. The use of natural techniques and products for new components responds well to the principles of compatibility. A more thorough study was carried out in order to define the types of works required for structural consolidation and substitution of part of the roof trusses with new Polanceau style trusses (Fig.8). For the insulation of the exteriors, products and technologies were tested in relation to: the thermal insulation of walls and in particular materials for insulation in the interiors; thermal insulation of the roofs; thermal insulation and work on the ceilings which were in contact with unheated areas (Fig. 6). Feasibility studies were carried out on the following solutions for the production of electric energy, heating and cooling: a cogeneration or trigeneration system with varying system configurations and water to water heat pumps using groundwater. Lastly, an assessment was made whether or not it would be possible to substitute

part of the gas or diesel fuel consumption with biomass produced by the farm itself, or from nearby areas, with benefits for the environment and for the local economy.

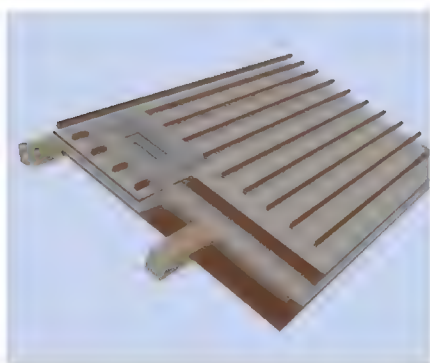


Fig.8. Zena castle. Thermal insulation with natural materials and substitution of damaged roof trusses with sustainable new ones.

## 5. Conclusion

In this era of mass communication, pure conservation has no choice but to work alongside of revitalizing and promoting cultural icons that translate the testimonials of the past into the language of the present. Restoration thus finds itself assuming the arduous task of defending heritage in a delicate balancing act between past and present, harmonizing tradition with innovation, multicultural strands of the vernacular with cross-border technological advances, historical realities with modern-day discoveries.

In our approach, cultural, technological, social, legislative, economic, energy and environmental parameters are evaluated, while our sustainable restoration plan must still be compliance with energy strategies. With the establishment of this scientific path, the frontier of restoration has become “*green*” and it is moving towards the concept of “*green conservation*”, which is a theoretical, methodological and technological approach that uses innovative principles to design interventions of conservation and functional restoration for buildings with significant historical and architectural value. Above all it tends to establish a design and performance method that is a “*model for technologically sustainable intervention*”.

In so doing, there is no reason why *sustainability* cannot also be “*greenability*”©.

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# MULTICRITERIAL APPROACH FOR THE EVALUATION OF THE COMPATIBILITY OF ENERGY PROJECTS IN HISTORICAL BUILDINGS BY AHP METHOD.

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## Abstract

It is possible to integrate energy saving technologies and renewable energy in today's society with respect to the cultural and architectural aspects of the historical buildings using tools to aid the decision how to integrate new functions, materials and techniques?

The aim of this paper is to analyze the link between utilization and conservation in the monuments and describe a new approach to develop evaluation models of the potential sustainable energy rehabilitation of historical buildings. The experimental model is based on a multi-criteria approach – the Analytic Hierarchy Process (AHP) – which introduces the use of expert opinions, complementary skills and expertise from different disciplines in conjunction with quantitative traditional analysis.

The main criteria used are: assess the impact of the proposed intervention in the light of the international conventions of conservation (Restoration Charts); assess energy efficiency; assess the environmental compatibility and assess the economic budgetary feasibility.

The tool is developed in the framework of the Sechurba project, an European initiative under the CIP program umbrella.

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**Keywords:** Multi-Criteria Analysis (MCA), Sustainable Energy Rehabilitation, Analytic Hierarchy Process (AHP), Rational use of Energy in Restoration projects.

## 1. Introduction

There are a huge number of historic buildings in Europe, and many of them are wasting large amounts of energy: this architectural heritage deserves particular attention within a sustainable approach, with regard to sustainable energy development and historic buildings protection. The potential of energy saving measures in historic buildings is of great interest, due to the increased building stock in European level, the particularities in their architectural form, typology and antiqueness of construction, the energy efficient initial design and their specific use and operation.

The aim of this paper is to analyze the link between utilization and conservation in the monuments and describe a tool to develop evaluation models for sustainable energy rehabilitation of historical buildings. The tool is developed by CNR - ITABC Built Heritage Laboratory, in the framework of SechURBA project “Sustainable Energy Communities in Historic URBan Areas”, an European initiative of the Intelligent Energy Europe Programme (IEE). SechURBA project, financed in the 2008 by the EU aims to demonstrate sustainable energy intervention in historic urban areas and buildings respecting culture, heritage and local character. The project is working in historic communities and buildings in 10 case study communities to demonstrate how by addressing barriers, they can contribute to cultural, social, economic and environmental objectives and enable governments to exceed their statutory climate change requirements. SechURBA is implemented in 7 European countries and project activities are carried out by 13 organizations from Universities, Research Centers, National and local energy centers, Municipalities. One of the main task of CNR-ITABC team was the development of a new, highly innovative and comprehensive Intelligent Application Tool to identify appropriate sustainable energy solutions and achieve best practice in complex situations such as historic buildings [1]. The work is based on these particular assumptions:

- It's possible to integrate energy saving technologies and renewable energy in today's society, with respect to the cultural and architectural aspects of the historical buildings.
- Protection of historical monuments and the modernization of old buildings to low energy standard can go together very well.
- Tools to aid the decision how to integrate new functions, materials and techniques are missing.

The proposal approach differs from the traditional design/build process, as the design team examines the integration of all building components and plants and determines how they best work together to save energy and



reduce environmental impact. A proper intervention for energy conservation in historical building should ensure that: a) the building is well studied and deeply understood; b) the changes carried out can be easily reversed without damaging the existing fabric, and c) attention must be given to new materials and techniques designed for new construction. At the same time, it's also essential that interventions won't alter the elements that make up the special historical character of the building.

The situation as described above means that it is necessary to find a procedure for decision making that includes and compares all possible parameters. At the present state of knowledge, the best procedure available for this purpose is the Analytic Hierarchy Process (AHP), a process by which complex decisions can be structured so that a systematic, optimal and rationally comprehensible decision can be reached [2]. The Analytic Hierarchy Process (AHP) was developed in the early 1970's by Thomas L. Saaty of the University of Pennsylvania and has since come into the mainstream of conventional multicriteria decision analysis. This process has methodological tools for structuring the decision problem, weighting criterions/goals and alternatives and analyzing judgment consistency, and it constitutes a comprehensive method of evaluation to support decisions for which both quantitative and qualitative attributes are relevant. AHP has four major features: it decomposes a complex problem into its constituent elements and orders them into a "hierarchy", or classification system; it uses pairwise comparisons to establish priorities among elements in each level of the hierarchy; it provides a measurement theory to estimate the relative weights of the elements; and aggregates the relative weights to derive a single overall rating for each decision alternative [3].

## 2. A simple Multicriteria decision model for compatibility assessment of energy-saving projects in historical buildings

A Multicriteria approach for compatibility assessment of energy-saving projects in historical buildings must be rigorous in concept, but straightforward to apply. It is not designed to replace expert judgment, rather structured for decision-makers to make more transparent and consistent decisions. While the final decision will be made based on the performance of alternatives, a well-defined criterion set and preference are key influential factors and should be prepared in advance [4].

The Multicriteria Decision model proposed for compatibility assessment of energy-saving projects in historical buildings is basically articulated in four steps:

1. Define the main goal and the evaluation criteria and sub criteria - to compare the different proposals for evaluation – and to structure them into a hierarchy.
2. Building analysis and energetic diagnosis.
3. Suggest proposal for energetic rehabilitation.
4. Building the AHP hierarchy, assessment process, final scoring and ranking of alternatives.

### 2.1 Define the evaluation criteria and sub criteria and structure into a hierarchy

In order to obtain preference structure, our research group carried a preliminary analysis to define assessment criteria, through the study of international documents on historical rehabilitation and energy building efficiency tools. The expert team defined the follow four main comparison criteria and 12 sub-criteria for compatibility assessment of energy-saving projects in historical buildings:

1. Assess to the international Conventions of Conservations, with respect to the main principles of the European Charters of Restoration: Reversibility (the possibility to undo work and bring the fabric back to its original state), Compatibility between new and old, Minimum intervention, Legibility of new works against the existing.
2. Energetic Effectiveness, in order to maximize the energetic performance of the building and saving energy
3. Environmental Sustainability, in order to minimize environmental pollution, and to use as much as possible renewable resources.
4. Economic feasibility, in order to achieve low cost and to minimize yard timetable and to return capital in relation to costs.

Next step involves the development of a hierarchy structure for assessment: a hierarchical analysis was carried out using an "expert based" approach, and comparing alternatives using AHP. The criterion *Assess to international conventions of conservations* receives the highest priority (0.46) relative to the other criteria. *Energy efficiency* has the second highest priority (0.24). *Environmental sustainability* has the same (0.15) than *Economic feasibility*.



## 2.2 Building and site analysis and diagnosis.

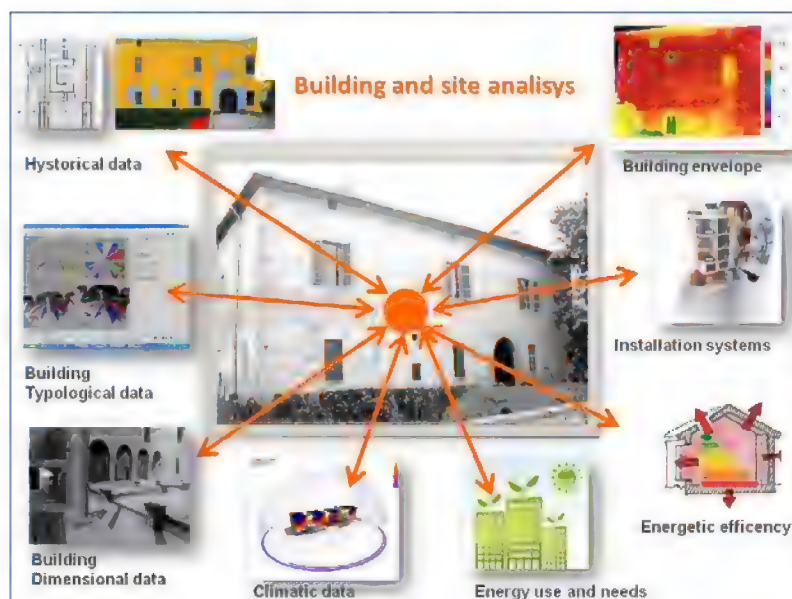


Figure 1. Building and site analysis and diagnosis

A certain amount of information is necessary to develop a decision model. For an energetic rehabilitation on historical building, the key aspects to consider are many and complex: site information, building typological, historical, and dimensional data, climatic data, energy use and requirement for heating, hot water generation and cooling, etc., energetic diagnosis, and many others, such as expert interviews, environmental and historical research, analysis of maps and aerial photography, etc (Fig. 1).

For collecting data, a checklist has been developed by our research group. The proposal template is organized in 7 different sections: general data (information about building, and to indicate real estate, year of building, typology, type of use, listed building, etc.); climatic data (daily degree, external temperature, building solar orientation, rainy conditions, roof exposure, etc.); structural elements (structural elements of building, their importance from historical point of view, conservation state); energetic data (energetic efficiency, presence of weak point, reparability, etc.); building Energy Balance (indicate surfaces, volumes heated and non – heated, external wall transmittance, energetic transfer index, energy building class, etc. (this section is important to evaluate the energetic efficiency of the building, and useful to compare the energetic rehabilitation of the building before and after the interventions); existing building plant (cooling, heating, lighting and ventilation plant) and plant efficiency diagnosis; energy performance requirements and needs.

## 2.3 Suggest proposal for energetic rehabilitation alternatives.

In the past years a great number of technologies have been developed for energetic rehabilitation. In addition, depending on building conditions a wide variety of alternatives are available. Due to the wide range of alternatives, a method for screening out some alternatives prior to perform a detailed analysis using decision support systems becomes necessary [5]. For collecting data, a checklist has been developed by our research group, used by all partner of SechURBA project to suggest new rehabilitation techniques and strategies, and collect these in a Renewable Energy Source (RES) and Rational Use of Energy (RUE) Database, open to all partner. The proposal draft is organized in different sections containing information about energetic rehabilitation technologies and building element class. The first section is “RES – RUE Technical Description” that describes proposal of energetic rehabilitation in historical building, and indicates the building element class (structures; outside wall; inside wall; standing finish; windows and doors frames; roof; cover floor; ground floor); building performance (Rooms Heating, Rooms cooling, Lighting, Hot water heating, electric energy, and indicate the technologies or method used; performance class (energy performance class of the proposal: insulation, heating/cooling, energy production, energy saving, hot water production, water supply and reuse, ventilation, lighting, soundproofing). In the second section “Building Performance Rating”, expert have to evaluate the proposal made in accordance to the four assessment criteria (Assess to international conventions of conservation; Energetic effectiveness; Environmental sustainability; Economic feasibility) and relative sub-criteria. The evaluation scale is based on qualitative judgment, quantified by fitting five different degrees of preference (very strong, strong, medium, low, none). Given this information, it's possible to determine a first weighted evaluation for each of the proposal alternatives. All data are collected in a RES RUE database, a free archive open to all.

## 2.4 Building the AHP hierarchy and measurement of data collection.

The next phase concerns the building of the AHP hierarchy and the measurement of data collection. In this step, alternatives are compared by an expert team of evaluators composed by: a) building technicians (architects, engineer, restorers, plant engineering, designer, etc.), b) policy makers (European, national and local governments, cultural and heritage organizations are often responsible for strategic and planning framework development and interpretation, company buildings, etc.), c) energy and climate organizations (include SECHURBA national leaders, influencing policies; energy service company, etc.), d) local energy markets (technology manufacturers, developers and energy utilities which through funding programs can be leaders in innovation, energy services and white certificates, etc.), e) citizen and community (citizens and historic community, residents associations and local partnerships with other key actors; organizations - e.g. housing associations- owning historic buildings, etc.). Expert team compares alternatives using pairwise comparison, with respect to each one of the criteria and sub-criteria in the preceding level (assess the impact of the proposal intervention in the light of the international convention of conservation; assess energy efficiency, assess environmental sustainability, assess economic feasibility). In order to implement analysis and valuation, an open source software for decision support systems ("Super Decision") was used. When expert team completed all comparisons, software automatically calculate and graph the best alternative, one list for each criteria. The results can also be graphically displayed in different combinations so that the comparison between alternatives is made easy (Fig. 2).

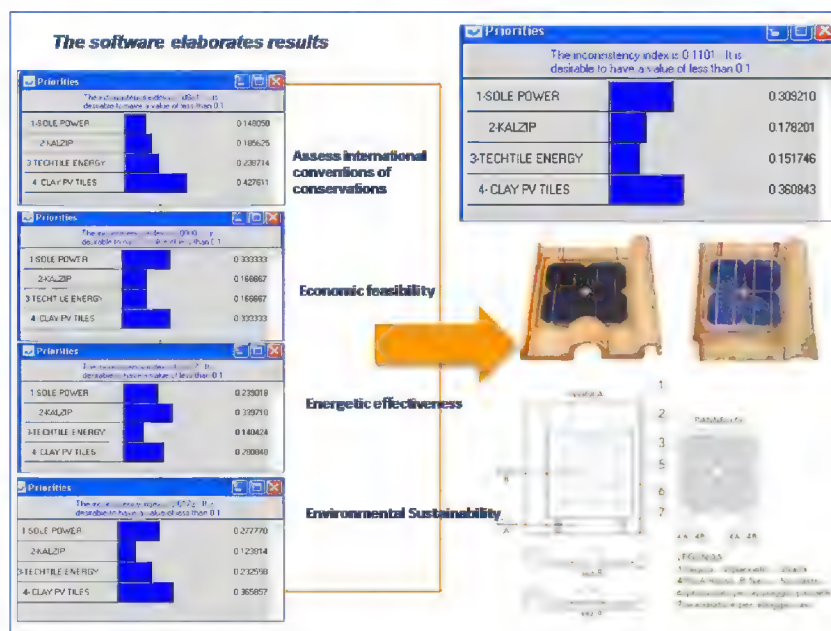


Figure 2. Combining the criteria scores to produce a ranking of each solution with the software aid.

## 3. A case study. The Castle of Zena

The tool was used in the restoration and technological adaptation of Zena Castle, a monument in the northern part of Italy, near Piacenza [6]. The interventions planned for technological and energy efficiency adjustments consist substantially of: increasing the seal and insulation in the building enclosures (exterior walls, roofs and ground floors, shutters, doors and windows), therefore reducing the heating requirements; reusing some of the attic areas that meet the necessary sanitary and hygienic requirements for occupancy as living quarters, for optimum recovery of space; restoring accessibility and functionality to the eastern wing that was abandoned after the collapse of the intermediate floors, which had increased structural fragility; recovery of the basement areas from both a conservative and functional standpoint; design of an innovative energy production system for the entire architectural complex, also through the use of renewable sources to reduce energy consumption, for air conditioning during the summer and heating during the winter, the production of hot water and lighting of the indoor and outdoor areas.

The possible solutions for thermal insulation of the perimeter walls are only on the interior side, since the exterior sides are constructed in fine mortar and visible brick, and the walls do not have an empty core. The ample thickness of the walls nevertheless provides an acceptable U value. The interior insulation was adopted in these two historic "service" areas of the castle which are therefore free of any frescoes, wall decorations or fine flooring. In these areas, a ventilation space with recycled plastic cement casings will be created for the ground floors, and internal insulation with wool and wooden fibre panels covered in insulating mortar for the walls. In these same areas, it was possible to design the radiant heat and air conditioning system powered by a geothermal pump, which uses superficial groundwater as a heat source, also supported by the presence of several wells on the property.



The role of the roof in the thermal insulation of the building is significant. The precarious conditions of the load bearing trusses and the roof covering require the disassembly of the roof, allowing the creation of a ventilated roof to offer maximum comfort and durability of the structures (Fig. 3). On the exterior, interventions were made to improve the insulation performance of the existing door and window frames, which constitutes one of the main causes of heat dispersion, by replacing the windows with triple-layer low emission glass, with Argon gas in the core. In regards to the systems, several possibilities were analyzed for integration. An integrated system was chosen: a trigeneration system, which also permits autonomous production of electric power and water to water heat pumps using groundwater.

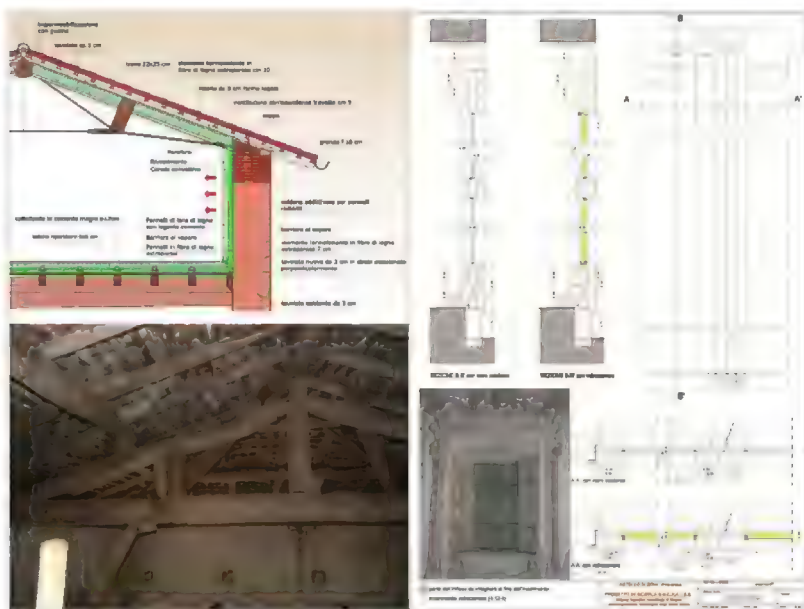


Figure 3. Some of the identifies solution for an integrated energetic rehabilitation of the Zena Castle.

## 5. Conclusion

If we consider how much energy is dispersed into the monumental buildings in which we live, we realize that these manmade structures, extraordinary symbols of history and art, are certainly antiquated in respect to our living requirements, which are quite different from those of the men who built them centuries ago. Today, relying on research, technological innovation and energy efficiency is a must for the scientific sector, but also for the productive sector which deals with these assets.

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## SESSION A3 – HISTORICAL CITIES: SEISMIC EMERGENCIES

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### EARTHQUAKE RISK REDUCTION TO STATE MUSEUM COLLECTIONS IN TURKEY

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Earthquake poses the highest risk among all natural disasters in Turkey. Located at the junction of the African, Arabian and Eurasian tectonic plates, Turkey is subject to continuous earthquakes in three major fault zones that place two-thirds of the country.

92 museums are state museums that work under the auspices and authority of the Turkish Ministry of Culture and Tourism among 300 museums in Turkey. Collections of state museums are mostly ethnographical and archaeological which contain diverse conceptual values. However, most of the unsecured museum collections are vulnerable to earthquake and unfortunately, some of the objects in storage areas as well as on display were almost damaged in the past earthquakes.

**There have been several attempts such as seminars, trainings or projects to draw attention to the earthquake vulnerability and risks of museums, however, little advancement has been made toward development and implementation of mitigation methods in respect to the safety and protection of museum collections as well as museum buildings against earthquake.**

The paper is an output of a post-doc research entitled “Reducing Earthquake Risk to Museum Collections in Turkey”. It provides information on the current situation of state museums in terms of staffing, collections, buildings, exhibition galleries, storage areas, disaster experience, earthquake preparedness as well as mitigation methods and materials. The paper discusses the challenges faced when taking mitigation methods as well as needs and priorities, and concludes with the recommendations for the future activities.



# SEISMIC PERFORMANCE OF ANCIENT TIMBER-FRAMED WALLS

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## Abstract

The objective of this paper is the investigation of the behaviour of traditional timber-framed masonry structures subjected to seismic forces and the formulation of numerical models for use in structural analysis. Firstly, a retrospection of timber-framed structures from the Bronze Age to the present day is presented. Particular attention was paid to investigating the historical continuity of them. In the next part the seismic performance of these structures is investigated according to statistical data from recent earthquakes and finally an analytical model capable of describing their performance is developed. With reference to a basic panel of a conventional timber-framed masonry building, a non-linear model is developed, aiming at capturing the key inelastic mechanisms. The analytical model is implemented in the finite-element code ANSYS and validated against experimental results.

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**Keywords:** Timber-framed masonry; Historical retrospection; Seismic performance; Plasticity model; Non-linear static analysis

## 1. Introduction

Lately there is a rising interest in understanding the behaviour of traditional structures which have survived over the centuries, often in seismic-prone areas, and need preservation. Necessary constitutive models and analysis techniques have become available for unreinforced masonry structures. Despite this fact very little progress has been attained regarding the modelling of timber-framed masonry which is a special type of masonry. The analysis of these structures is usually performed with elastic methods [1-5]. Elastic analysis is a useful tool for identifying regions with high stresses. However, it fails sometimes to capture the final failure mechanism.

This work first provides an insight into the development of timber-framed masonry over many centuries; then the seismic performance of these structures is investigated. An analytical, plasticity-based model is presented for the inelastic analysis of timber-framed masonry structures. The proposed model is applied to the analysis of three timber-framed masonry walls that were tested in the laboratory by Santos [6].

## 2. Retrospection of timber-framed structures

### 2.1 Bronze Age

Timber-framed masonry was occasionally used in Bronze Age Greece. Remains of timber-framed masonry buildings in the Bronze Age are detected in Minoan Crete, Mycenae and the island of Thera. The fundamental characteristic of the construction practice of this period is the use of one timber framework on each face of the thick masonry wall, sometimes linked together.

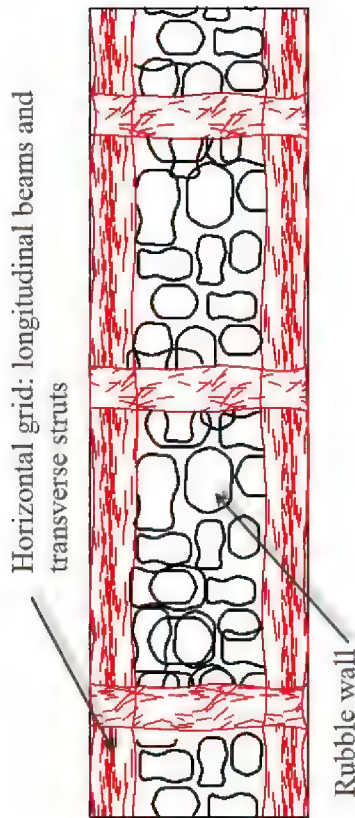
In Minoan architecture of Bronze Age Crete wooden framework techniques often have simple technology. A few horizontal and/or vertical timber members were embodied into rubble walls (Fig. 1). Wooden frameworks within rubble walls were more commonly used in multi-story structures. Not all Minoan dwellings incorporated timber reinforcements within walls and when they did, this was just in parts of the building. Furthermore, horizontal timber components were often embedded at the top of the masonry walls joined at the corners. They could add sufficient tensile strength to resist forces which might separate intersecting walls, acting like a tie-beam. This anti-seismic precaution is found at Knossos, Tylissos, Phaistos, and elsewhere in Minoan Crete [7].

The construction practices in Mycenae match Minoan architecture found at Knossos. The framework consisted of a horizontal wooden grid made of longitudinal and transversal members and/or vertical posts on each face of the wall [8].

One of the five structural systems identified in the important Aegean settlement of the island of Thera consists in timber-framed walls. The town of Akrotiri was buried in the lava of the great eruption from the volcano of Santorini around 1500 B.C. The insertion of notched interlocking longitudinal beams on each face of the walls tied together at intervals by transverse struts, at the corners and at crossing interior walls is quite common. It was probably applied as a type of timber reinforcement and was used for connecting the rubble material of masonry walls and adjoining transversally-crossing walls [9]. The complete timber-framed masonry system consisted of horizontal beams and vertical posts, it is found in a few cases of multistory buildings. The 7m height remains of the 3-story building Xeste-2 is a typical example of timber-framed masonry formed by ordinary wooden frames with masonry infill.

The Minoan, Mycenaean and Thera builders first constructed the timber framework, and the stone or brickwork was then added. Naturally, very little carbonized timber has survived and cavities between the stone courses constitute the evidence. Horizontal cavities generally extend from 15 to 25cm into the wall. Vertical cavities are

about 20cm wide; they extend through the wall on every face and from top to bottom. Horizontal cavities have a vertical spacing of about 0.8m. The first longitudinal beam was placed either on the floor as a baseboard or about 1m above the floor.



**Fig. 1.** Section of timber-framed masonry.



**Fig. 2.** Timber-framed walls from the excavations in Herculaneum (IT).

### 2.2 Classic civilization

There is no obvious evidence of the use of timber-framed masonry during ancient Greek times. On the contrary there is a very important archaeological finding accompanied by written evidence for the existence of timber-framed masonry structures during the Greek-Roman times in the region of the Gulf of Naples in Italy. The town of Herculaneum was covered with a thick layer of lava after the eruption of Vesuvius in 79 AD. Archaeological excavations 20m deep brought into the light timber-framed walls (Fig. 2) which were identified as one of the masonry construction typologies described by Vitruvius as ‘Opus Craticium’. Timber elements had approximately square cross section with side 10-12cm. The type of construction is very close to contemporary one-layer thin masonry.

### 2.3 Medieval Centuries

Timber-framed masonry was extensively used during the Middle Ages. Horizontal timber elements incorporated in masonry walls were commonly used in Byzantine churches [10], defense walls (Fig. 3), monasteries [11] and other large structures. Timber-framed masonry is predominant in late middle-age Tudor architectural style in Britain.

### 2.4 Modern times

The timber-framed masonry was used as an earthquake-resisting structural system at least from the 18<sup>th</sup> century in seismic-prone areas. In some interesting cases it seems to appear as a precautionary measure, introduced after strong seismic events.

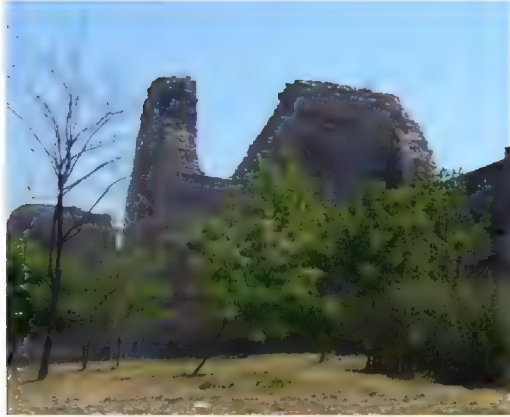
After the disastrous earthquake of 1755 the centre of Lisbon was rebuilt with provisions for the seismic safety of the buildings. Timber-framed masonry with diagonal braces was used to provide seismic capacity [2]. ‘Casa Baraccata’ also consisted of a wooden internal frame with diagonal braces invisible from the outside and the external masonry wall, connected to each other [12].

Another timber-framed masonry system is found in Lefkas, Greece in which the dual system consists of the ground stone-masonry floor and the upper timber-framed stories [4,11,13]. The upper stories are carried from the stone-masonry ground floor but in case of collapse, a secondary supporting system of timber columns is activated. These columns are either fixed to the ground or, more often, free standing. These two systems are initially joined. Many heritage buildings of timber-framed masonry but with diagonals in lieu of this dual system are found in Macedonia (Fig. 4) and the settlement of Eressos in Lesbos, Greece [14].

### 2.5 Nowadays



Nowadays, many heritage buildings of timber-framed masonry are used as dwellings but many of them are exposed to high seismic risk. Some of them stand in Lefkas, Macedonia and Eressos (Greece), Lisbon (Portugal), Calabria (Italy) and other cities and countries.



**Fig. 3.** Below the courses of red bricks of the Theodosian Walls of Constantinople (408-413 AD) there are longitudinal wooden beams.

dominates the entire response. In the final stage masonry infills cannot undertake the large deformation of the flexible surrounding timber frame and they fall down crushed in the edges (Fig. 6d). The diagonal braces lose their original geometry and collapse of the wall follows.

### 3.2 Seismic performance of timber-framed masonry structures during recent earthquakes

The epicentre of the Lefkas earthquake in August 2003 was near the city. 34% of the building stock consisted of timber-framed traditional buildings [4]. Although the earthquake was intense ( $M=6.4$ ) and a few R/C buildings collapsed, damage to timber-framed buildings was limited to out-of-plane fall of external mortar or a few masonry infills. During the Düzce (1999) and Orta (2000) earthquakes in Turkey no collapse of timber-framed buildings was observed, although some R/C buildings did collapse [15-17].



**Fig. 4.** Typical timber-framed masonry building with diagonals in Goumenissa (GR).

### 3. Seismic performance of timber-framed masonry structures

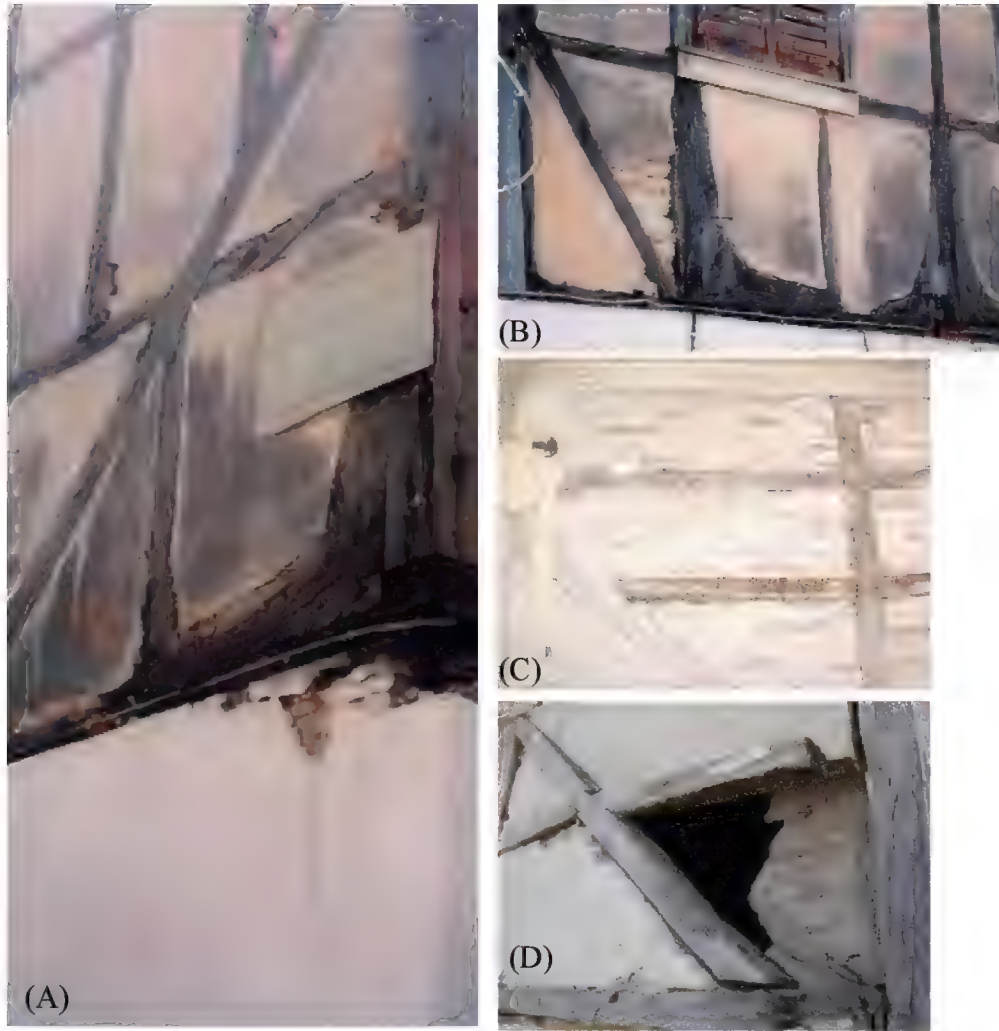
#### 3.1 Description of seismic performance of timber-framed masonry walls

A timber-framed masonry wall which consists of two diagonal braces, the surrounding timber frame and the masonry infills (Fig. 5), is subjected to a horizontal load acting at the top. In an early stage the panel behaves like a body and during the very first movement, cracks appear in the external mortar (Fig. 6a). At the second phase of the loading external mortar falls down (Fig. 6b). These two phases constitute the linear response which constitutes a small part of the total one.

During the third phase, which is very important for the overall performance of the wall, shear failure of the cohesion between timber elements and masonry infills appears and sliding between them initiates (Fig. 6c). This part of the loading



**Fig. 5.** The basic panel of timber-framed masonry, consisted of the timber frame, the timber diagonals and the masonry infills, is forced with a horizontal load.



**Fig. 6.** Basic stages of the performance of timber-framed masonry: (a) cracks in the external mortar, (b) external mortar falls down, (c) sliding between timber elements and masonry infills by [4], (d) crush of masonry infills by [4].

#### 4. Analytical model for timber-framed masonry walls

##### 4.1 Description of the analytical model

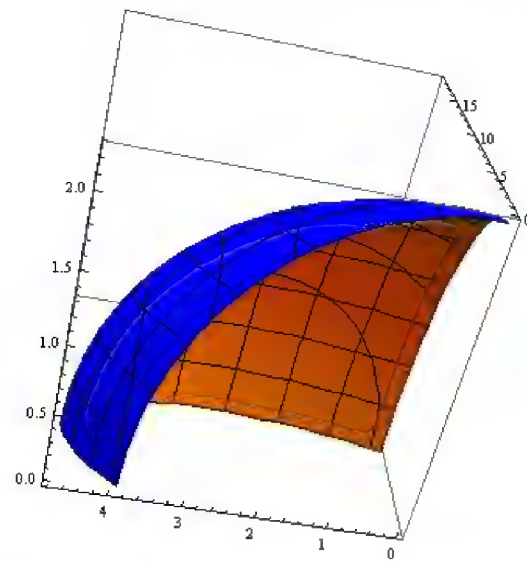
Timber-framed masonry consists of three fundamental materials; bricks (usually clay fired bricks or sun-dried clay bricks, or stone bricks), mortar, and wood. Bricks and mortar constitute the brickwork which seldom has high strength (and modulus of elasticity) and wood constitutes the timber frame. Masonry infills affect the performance of the walls only during the first small part of the elastic response. In a model aiming at the inelastic response, masonry infills are commonly omitted. The result is lower elastic stiffness but better capturing of the entire response.

Wood is an anisotropic material but can be effectively modelled as an orthotropic material [18]. Wooden members are modelled with plane-stress elements. The adopted yield law and plastic potential function for timber is the orthotropic Hill law [19]. The final law for plane-stress analysis ( $\sigma_x = \tau_{xz} = \tau_{yz} = 0$ ) is the following equation wherein  $\sigma_{ij}$  is the stress in the  $ij$  direction:

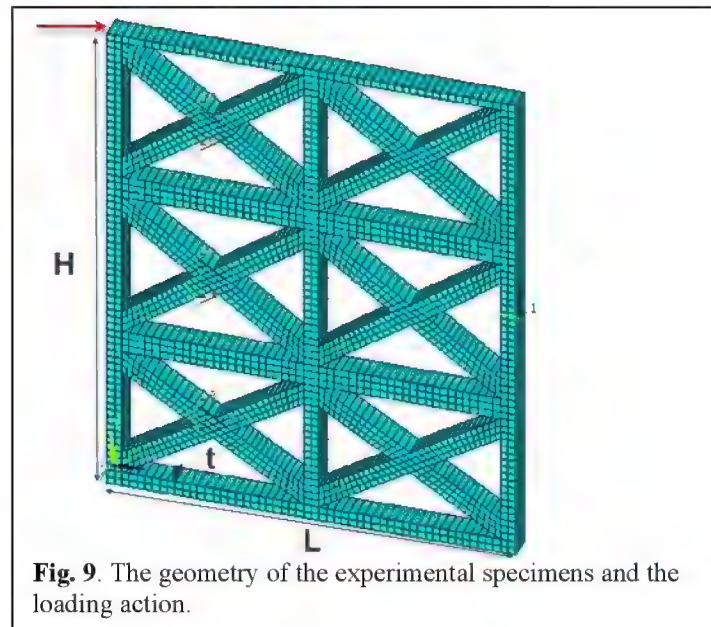
$$F(\sigma_{ij}) = f(\sigma_{ij}) - 1 = \frac{1}{2} \left( \frac{1}{\sigma_{yy}^2} + \frac{1}{\sigma_{zz}^2} - \frac{1}{\sigma_{xx}^2} \right) \sigma_y^2 + \frac{1}{2} \left( \frac{1}{\sigma_{xx}^2} + \frac{1}{\sigma_{zz}^2} - \frac{1}{\sigma_{yy}^2} \right) \sigma_x^2 + \frac{1}{2} \left( \frac{1}{\sigma_{xx}^2} + \frac{1}{\sigma_{yy}^2} - \frac{1}{\sigma_{zz}^2} \right) (\sigma_x^2 - \sigma_y^2) + \frac{1}{\sigma_{xy}^2} \tau_{xy}^2 = 1 \quad (1)$$

The above equation represents an ellipsoid whose section with the original orthogonal planes is drawn in Fig. 7. The material law for monotonic and uniaxial stress is considered trilinear according to the  $\sigma$ - $\epsilon$  law of Fig. 8.

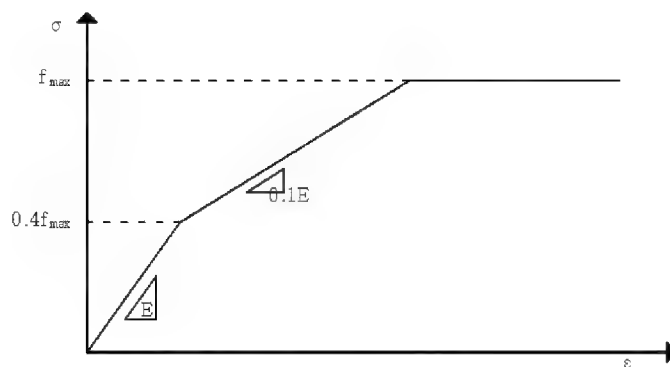




**Fig. 7.** The ellipsoid of the Hill law for plane stress.



**Fig. 9.** The geometry of the experimental specimens and the loading action.



**Fig. 8.** The trilinear diagram for tension under monotonic loading for timber.

The initiation of the plastic deformation is assumed to begin at 40% of the final strength. The flow rule is assumed to be associated for work hardening according to the following equation in which  $\varepsilon_{ij}^p$  is the plastic deformation in the  $ij$  direction,  $d\lambda$  a positive scalar factor and  $g$  is the plastic potential function:

$$d\varepsilon_{ij}^p = d\lambda \frac{\partial f}{\partial \sigma_{ij}} = d\lambda \frac{\partial g}{\partial \sigma_{ij}} \quad (2)$$

Due to the unreliable connection between timber elements it is assumed that there is simple contact without any monolithicity. The interface model adopted for the description of contact between timber braces and posts is the Mohr-Coulomb friction model without cohesion. The friction coefficient is assumed here to be equal to 0.5. For the surface-to-surface contact special contact and target elements are used and asymmetric contact is assumed [20]. The contact elements themselves overlay the area finite elements describing the boundary of a deformable body and are potentially in contact with the target surface, defined by the target elements. Each target surface can be associated with only one contact surface, and vice-versa.

#### 4.1 Validation of the proposed model

The proposed model has been validated with the results of laboratory tests performed at LNEC, Lisbon [6]. In the laboratory tests three specimens were taken from an existing building of Lisbon. These specimens had large dimensions, with about 3.5m height (storey height), about 2.5m width and about 0.15m thickness (Fig. 9). Basic geometrical data and experimental results are shown in Table I.

The experimental testing consisted of the application of a reversed horizontal force until failure of the specimens. The behaviour of the three specimens was similar; in the final stage of failure they showed disconnection of the wood braces with a consequent sliding and sometimes out-of-plane fall of masonry infills.

The above specimens were modelled in ANSYS according to the aforementioned method and were subjected to monotonically increasing horizontal loading (with displacement control). Basic data for wood material are shown in Table II. The final deformed stage presents damage similar to that observed in the test specimens (Fig. 10). The results of the analytical model in comparison with the experimental results are shown in Table III. Analytical pushover curves compared with the hysteresis loops from the tests show a very good agreement (Fig. 11). The elastic stiffness for the analytical model is slightly smaller (~5%). The maximum strength and the maximum displacement between the analytical model and the experimental results are very close to each other (Table III).

**Table I.** Dimensions [length (L), height (H), thickness (t)] and maximum strength (V).

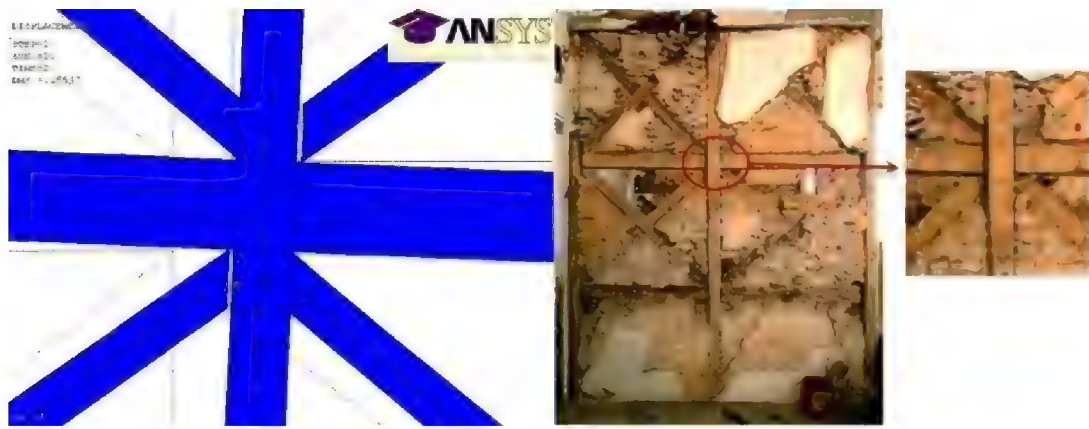
	L	H	t	V
	(m)	(m)	(m)	(m)
G1	2.53	3.59	0.15	71
G2	2.55	3.42	0.16	71
G3	2.67	3.36	0.17	60

**Table II.** Basic data for the wood material of the test.

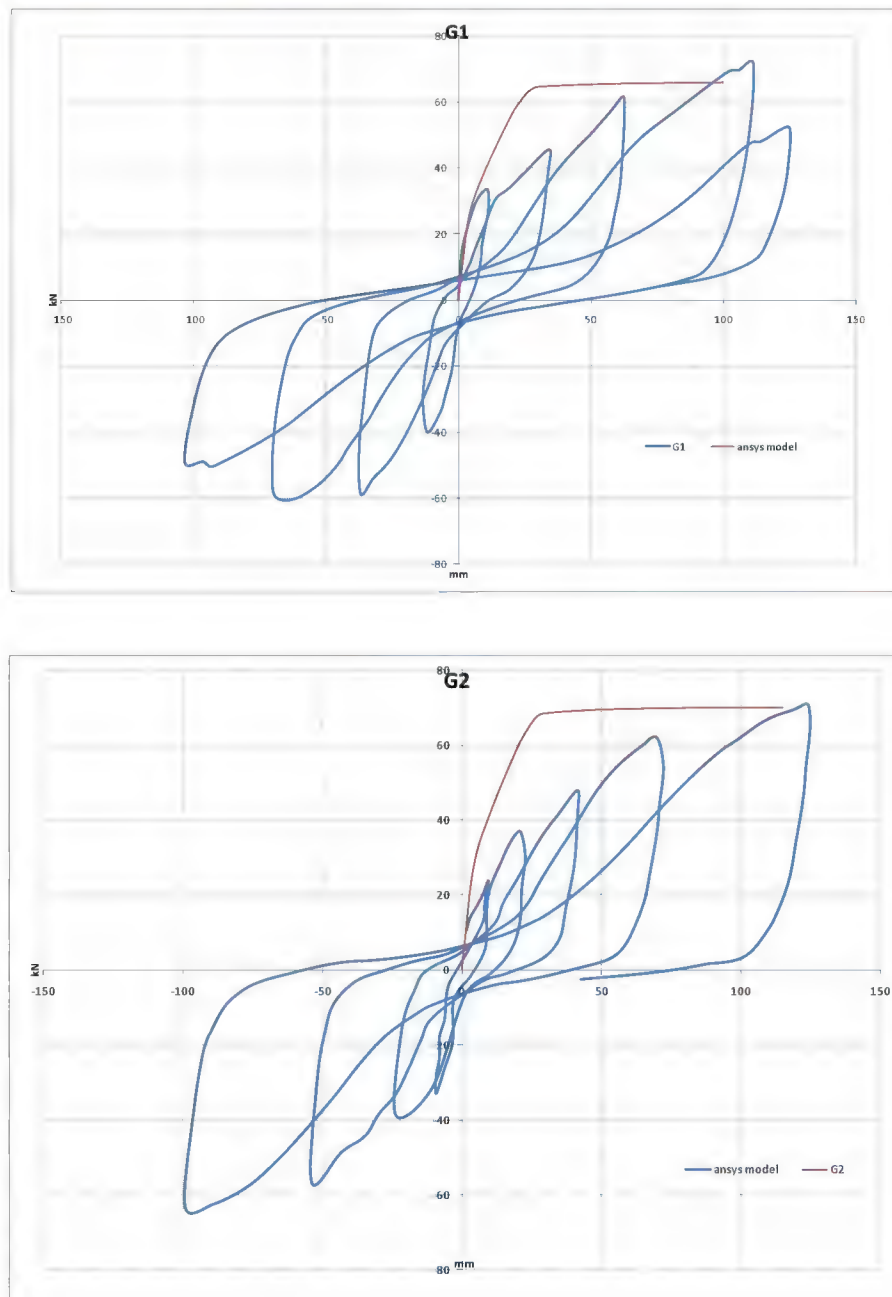
Direction	Strength	Elastic stiffness
	(MPa)	(MPa)
Longitudinal (xx)	19.25	$11 \times 10^3$
Tranversal (yy)	4.81	$0,37 \times 10^3$
Shear (xy)	3.85	$0,36 \times 10^3$

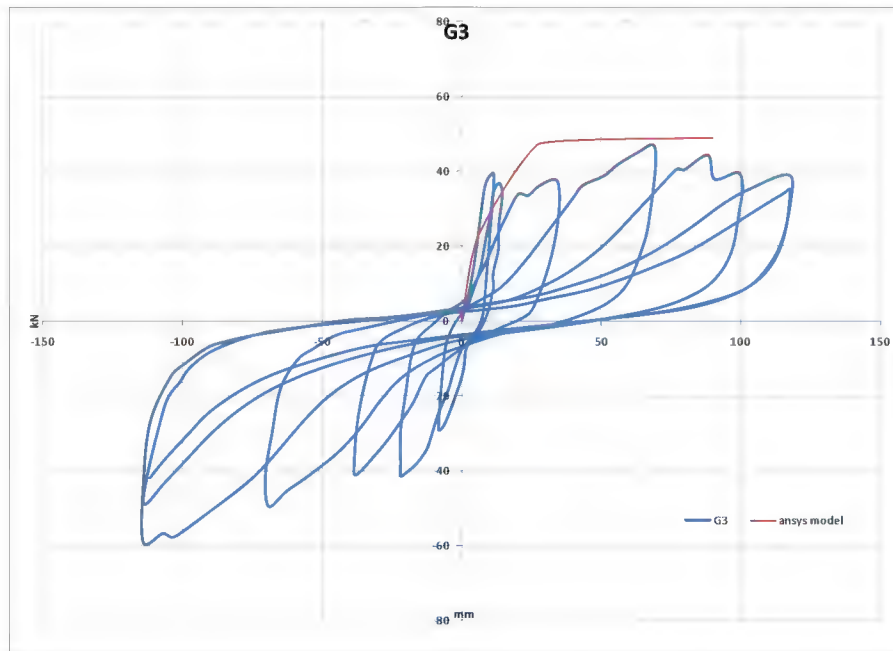
**Table III.** Elastic stiffness (kN/m), maximum strength (kN) and maximum displacement (cm) of the specimens.

		elastic stiffness	max strength		(%)	max displacement	
		(kN/m)	(kN)			(cm)	
G1	test	6733.36	71.61	-60.61	8%	12.50	-10.28
	ANSYS	6564.29	65.77			10.00	
G2	test	7711.08	70.98	-63.42	1%	12.28	-9.93
	ANSYS	7120.08	70.08			11.50	
G3	test	4361.08	46.77	-59.23	-4%	11.76	-11.42
	ANSYS	4049.97	48.81			9.00	



**Fig. 10.** The ultimate deformed shape of the central node of the analysis and one of the specimens of the experiment.





**Fig. 11.** Monotonic loading curves from the analytical model and hysteresis loops from the tests for specimens G1, G2 and G3.

## 5. Conclusions

The development of timber-framed structures is closely linked to earthquakes. From the Bronze Age to the present day timber-framed buildings are found in earthquake-prone areas. It can be assumed that timber-framed construction was developed as a practical technique to effectively resist earthquake damage. Particularly in the east part of the Mediterranean Basin the existence of timber-framed masonry has a continuous history of approximately 4 millennia. A model was developed considering orthotropic behaviour for timber elements and a proper interface, based on Mohr-Coulomb friction, for the interaction between them. The masonry infill is excluded from the model due to its insignificant contribution to seismic load resistance.

The method is validated here using the tests performed at the LNEC laboratory. A good agreement is found between the results of the numerical analysis and those of the tests.

## Acknowledgements

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# INNOVATIVE PROTECTION OF CULTURAL HERITAGE AND URBAN HABITATS AGAINST EARTHQUAKES AND OTHER NATURAL DISASTERS

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## Abstract:

Many highly populated cities worldwide, often enshrining precious heritage cores, are prone to natural hazards. Therefore, the accomplishment of accurate multi-hazard scenarios and vulnerability assessment procedures is a crucial tool to define mitigation actions. With regard to this issue, the paper deals with two significant researches: the EU COST Action C26 “Urban Habitat Constructions Under Catastrophic Event” and the “MAR VASTO” Project, funded by BID/IADB. Then, the development and application of passive vibrations control systems for the seismic protection of cultural heritage are illustrated. Italy is the worldwide leader in this field. In all the countries which are active in it, application includes the seismic rehabilitation or improvement of some important monumental structures, the construction of new museums and ceilings for archaeological excavations and the protection of single masterpieces. The so far developed and used devices and systems are shock transmitter units, shape memory alloy devices and (where possible) energy dissipation and seismic isolation systems. Similar to other anti-seismic techniques, the problem of the aforesaid systems (in particular, that of seismic isolation) is now the need for respecting the conservation requirements, which are very strict in some countries, like, for instance, Italy.

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**Keywords:** Multi-hazard mitigation, structural vulnerability, GIS database and building inventory, heritage protection, modern antiseismic systems

## Introduction

Everywhere in the world, most highly populated cities (but also many little towns and villages) are prone to natural hazards. The latter may be defined as processes, occurring in the biosphere, which may constitute damaging events. The main hazardous catastrophes (varying in magnitude, frequency, duration, extent area, onset speed, spatial dispersion and temporal spacing) are: earthquakes, volcanic eruptions, landslides, tsunamis, coastal erosions, floods, hurricanes, etc. With regard to urban habitats, both wild and man-induced fires can be also considered. Moreover, the city aggregates enshrine notable cores (like urban and social tissues, historical and architectonical constructions, precious monuments, museums and archaeological evidences) of invaluable value; such a kind of patrimony, which must be handed down intact to posterity as far as possible, is often protected by international and inland cultural heritage boards. Nevertheless, a huge amount of such treasures is lost for ever, due to past natural catastrophes; just some highlighting examples can be reminded: the 79 A.D. Vesuvius eruption, Italy (when Pompeii, Herculaneum and Stabiae were completely covered by pyroclastic flows); the disruption of San Francisco (California, USA) and Valparaíso (Chile) during the 1906 earthquakes followed by fires; the 1963 Vajont landslide, Italy (which swept away some small towns); the Florence flood (1966); the Lisbon great fire (1988); the Indian Ocean tsunami (2004), the Katrina hurricane (2005); and, as most recent devastating seismic events, those of Wenchuan in China (2008), Abruzzo in Italy (2009) and Haiti (2010). Thus, the accomplishment of an effective pre- and post-disaster risk management is a crucial tool, in order to minimize disaster impacts and implement potent policies and coping capacities of the society or individuals, managing the multifaceted nature of risk, realizing integrated hazard models and adopting appropriate governance for development and reconstruction planning [1, 2].

To achieve this aim wide-ranging R&D activities have been founded by the European Union (EU). Among these, a very significant research is represented by the EU COST Action C26 “Urban Habitat Constructions Under Catastrophic Event” [3], dealing with the outstanding topic of the protection of constructions in urban areas from exceptional loads, such as earthquakes, fire, wind, impacts, explosions and so on. The activities of this project have been divided into four Working Groups (WGs): Fire Design (WG1), Earthquake (WG2), Impact and Explosion (WG3) and Risk Assessment for Catastrophic Scenarios in Urban Areas (WG4). In the framework of WG4 (co-chaired by the first author of this paper), a case study on Vesuvius has been developed, probably one of the worst scenarios that can occur in complex and crowded urban areas [4].

A second important example of multi-hazard and structural vulnerability evaluation in heritage habitats is the Project “MAR VASTO” (Risk Management in Valparaíso/Manejo de Riesgos en Valparaíso, Chile), funded by Banco Interamericano de Desarrollo/InterAmerican Development Bank (BID/IADB) and coordinated by the first

author of this paper, with participation of Italian and Chilean partners and support of local Institutions [5]. Since Valparaíso has been declared patrimony of the humanity by UNESCO since 2003, the goals of the project were to evaluate the impact of the main hazards (earthquakes, tsunamis, fire, and landslides), carry out architectonic/urban planning studies and vulnerability evaluation for a pilot building stock in the historic area, provide a vulnerability analysis for three monumental churches, suggest guidelines for future urban planning and develop a Geographic Information System (GIS) digital archive [6-8].

Finally, the activities performed for the development and application of anti-seismic systems and devices shall be stressed. In fact, great efforts are being devoted in several countries to such activities, which concern all kinds of structures and valuable objects, including cultural heritage [9-20]. In keeping with the fact that Italy owns a large part of the cultural heritage existing in the world, this country is the leader in the field of its seismic protection by means of the aforesaid systems and devices; however, important activities have been undertaken in other countries, as well (e.g. in Japan, the USA, the People's Republic of China, the Russian Federation, New Zealand, Greece, Armenia, etc.). Application of the anti-seismic systems and devices concerns both the rehabilitation or improvement of some important monumental structures, the construction of new museums and ceilings for archaeological excavations and the protection of single masterpieces. The so far developed and used anti-seismic devices and systems are the Shape Memory Alloy Devices (SMADs), Shock Transmitter Units (STUs) and (where possible) Energy Dissipation (ED) and Seismic Isolation (SI) systems. With regard to SI, it is worthwhile stressing that this concept dates back to a long time ago, since rough SI systems were used by the ancient Greeks, Chinese, Incas, Persians and Anatolians (Plinius described that, sliding, of the Diana Temple in Ephesos in his "Naturalis Hystoria"). However, similar to other anti-seismic techniques, the problem of the aforesaid systems and devices is now the need for respecting the conservation requirements, which are very strict in some countries, like, for instance, Italy.

This paper deals at first with the above mentioned EU COST Action C26 and "MAR VASTO" Project; then it describes the features of the available anti-seismic systems and devices and discusses their applicability to cultural heritage, summarizing their use, with particular attention to that in Italy. This final part has been mostly taken from a recent publication of the second author of this paper [19].

## THE EU COST ACTION C26

Action C26 is part of the European COoperation in the field of Scientific and Technical research (COST). The Action main objective is to increase the knowledge on the behavior of constructions in urban habitat under catastrophic events, such as earthquakes, fire, wind, impacts, explosions, etc., in order to predict their response when both the applied loading and the inherent structural resistance are combined in such a way as to reduce the safety level below acceptable values, leading in some cases to a premature collapse. The EU signatory countries are 22 and the nearly hundred representatives are split into the four previously mentioned WGs [3].

Focusing on the WG4 activity (Risk Assessment for Catastrophic Scenarios in Urban Areas), the peculiar high risk situation of Vesuvius has induced the Action to introduce it as a case study, because this Neapolitan volcano has always represented a serious danger for the population living in its surroundings, causing death and destruction. Furthermore, particular attention has been devoted to the volcanic risk from a general point of view, in order to place Vesuvius in a global context. The research steps have been substantially two: the evaluation of the volcanic vulnerability of the urban environment towards a Vesuvius eruption, and the proposal of simple and economical mitigation interventions. The main results which are going to be achieved (to be considered as a starting point for future works) are:

- the qualitative and quantitative definition of the loading conditions on the constructions, produced by an explosive eruption, through a critical reorganization of the considerable scientific literature on this topic from the structural engineering point of view;
- the knowledge of the Vesuvius urban environment, directly improved by means of *in situ* survey activities in Torre del Greco, the most populated town of the Vesuvian area and probably that affected by the highest risk of the "red zone" around the volcano (Fig. 1); four different building stock typologies have been investigated: 281 buildings of the historic center, mainly masonry houses (Fig. 2); 20 masonry and reinforced concrete (r.c.) residential constructions, in the up-slope towards the crater; 15 public schools, again of masonry and r.c., located throughout the city territory; a set of 9 historic Vesuvian Villas of cultural importance (Fig. 3), among the 122 structures that still exist, mainly tuff masonry construction (the Villas are located along the "Golden Mile", i.e. the ancient royal road, inside an unique environment, parallel to the Tyrrhenian sea and crossing the towns of San Giorgio a Cremano, Portici, Ercolano and Torre del Greco, where the noble families erected elaborated palaces in the XVIII century);



Figure 1. Volcanic risk in the Vesuvius area. It is the result of the three factors: the elevated exposition value, due to the urban population density (about 800.000 inhabitants within a 7-8 km radius from the vent); the high probability of a large-medium explosive eruption in the next decades; the vulnerability of the urban settlements to eruptive events.



Figure 2. The historic center in Torre del Greco and classification of vertical walls, roofs and openings.



Figure 3. Some pictures of the Vesuvian Villas investigated.

- the construction identification was performed through an extensive visual examination, accompanied by the compilation of an *ad hoc* form, taking into account parameters influencing the volcanic/seismic vulnerability, such as the main vertical and horizontal structures, regularity in plan and in elevation, age of the construction and its conservation state; type of roof structure, shape and sizes of the openings, as well as their protection;
- the collected data have been used in the application of a 'quick' type methodology, extended to the whole sample (Fig. 4) [21]; the damage evaluation model has been tested for the eruption 'Sub Plinian I', considering the combination of three volcanic phenomena, i.e. earthquake (EQ), ash-fall (AF) and pyroclastic flow (PF), as shown by Figures 5-7 [4].



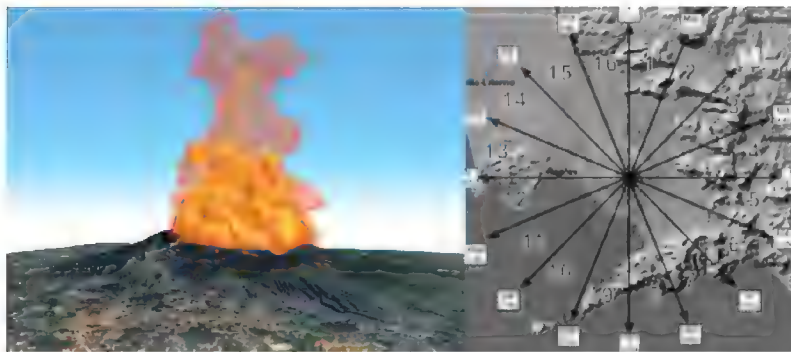


Figure 4. EXPLORIS project: Sub-Plinian I Vesuvian eruption simulation (left) and 16 radial sectors representative of different wind profiles (right).

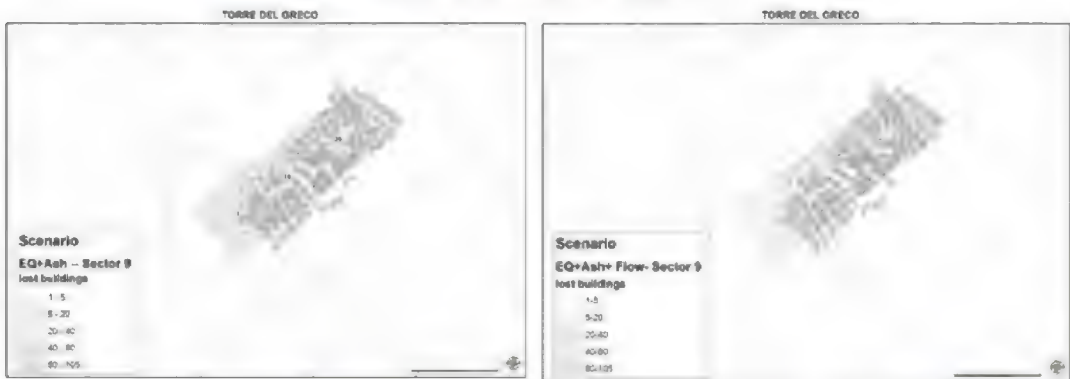


Figure 5. Examples of eruptive damage scenario in terms of lost buildings under the effect of earthquake (EQ), ash fall (AF) and pyroclastic flow (PF) for the sector 9.



Fig. 6. Earthquake: wall structural vulnerability classification. Fig. 7. Ash fall: roof structural vulnerability classification.

### 3 THE “MAR VASTO” PROJECT

#### 3.1 Goals, partnership and support of local Institutions

Italian and Chilean partners and the Abdus Salam International Centre for Theoretical Physics (ICTP) of Trieste formed the team which developed the “MAR VASTO” Project; the Italian partners were ENEA (coordinator) and the Ferrara and Padua Universities, while the Chilean ones were the Technical University Federico Santa Maria of Valparaíso and the University of Chile at Santiago [5]. Since Valparaíso has been included in the UNESCO World Heritage List of protected sites since 2003, the project main goals were the following: to provide maps and scenarios for the main hazards (earthquakes, tsunamis, landslides, fire); to develop a GIS digital archive, user-friendly and easy to be implemented, managing the information; to perform a vulnerability analysis for some historical structures made of various materials (masonry, concrete, wood and adobe) and located in different city sites; to suggest guidelines for future urban planning and strengthening interventions. Several Chilean Organizations cooperated with the Italian team: first of all the Valparaíso Municipality, providing logistic and technical support; the Regional Authority (Intendencia V Region Valparaíso); the Church; the Civil Defense (OREMI); SHOA (Servicio Hidrográfico y Oceanográfico de la Armada de Chile); PRDUV (Programa de Recuperación y Desarrollo Urbano de Valparaíso); the Firemen (*Bomberos*) and the Sea Rescue (*Bote Salvavidas*) Corps of Valparaíso; the Valparaíso Board of Architects, several professionals and other Universities; the Police (*Carabineros de Chile*); the Valparaíso

Italian Community. An important was also provided by Geocom Santiago, which provided the laser-scanner equipment. Moreover, qualified professionals of the Valparaíso Municipality received short duration grants in Italy, funded by the Italian Latin American Institute [6-8].

### 3.2 A brief description of Valparaíso

Valparaíso represents a distinctive case of growth, inside a remarkable landscape, of an important Pacific Ocean seaport (over the XIX-XX centuries), up to reaching a strategic importance in shipping trade, declined after the Panama Canal opening (1914). Thus, Valparaíso tells the never-ending story of a tight interaction between society and environment, stratifying different urban and architectonic layers, sometimes struck by disasters and always in danger.

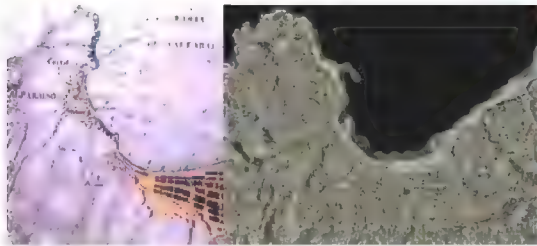


Figure 8. Valparaíso: origin and present situation.

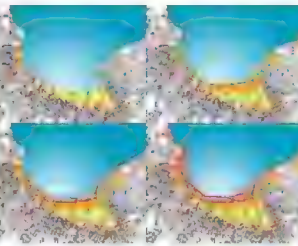


Figure 9. Growth of Valparaíso on reclaimed lands.



Figure 10. Valparaíso: the flat area and the harbor.



Figure 11. Valparaíso: buildings in the flat area.

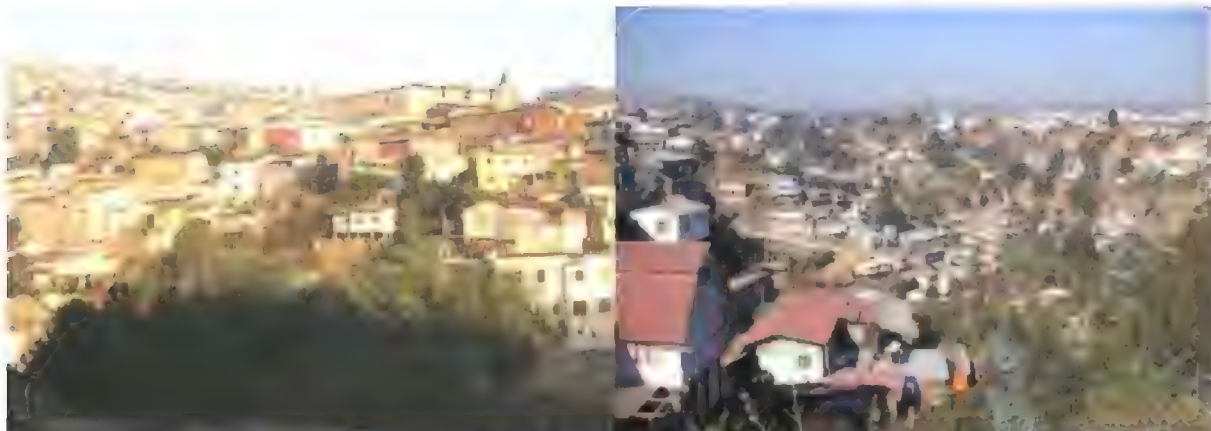


Figure 12. Valparaíso: the hills quarters.

The Valparaíso morphology can be roughly divided into two main sectors: the flat harbor area and hill quarters. Large neoclassic masonry buildings, some previous colonial style constructions (still standing structures spared by earthquakes and following fires) and more recent architectures take place in the commercial district, with straight streets, highways and rail tracks parallel to the coast. A wide area is occupied by port facilities up to the waterfront. Otherwise, the steep forty nine hills, cut by ravines (*quebradas*) and climbed by narrow and snaky lanes, are deeply filled by small and squat houses, typically made of wooden frames, adobe panels and covered by zinc tinplate (*calamina*); in addition to those pervading clustered homes, notable historical buildings are present (Figs. 8-14). This fact makes Valparaíso a city “with and without architects”. Several old cable cars (*ascensores*) ascend the slope (Fig. 15).

The historic district (Barrio Puerto, protected by UNESCO) lies in the Valparaíso Southern part and embraces a sector which, starting from the flat, reaches the hills (red line, Fig. 16). Furthermore, the entire city portion within the hills amphitheatre (green line, Fig. 16) was declared protected area by the Valparaíso Municipality. Certainly, the city is subjected to various natural hazards (seismic events, but also tsunamis, landslides, etc.) and anthropic calamities (mainly wild and human-induced fires). These features make Valparaíso a paradigmatic study case about hazard mitigation and risk factors must be very well evaluated during the restoration phases to be planned in the future.





Figure 13. Valparaíso: buildings in the hills.



Figure 14. Valparaíso: a city “with and without architects”.



Figure 15. Examples of Valparaíso cable cars.



Figure 16. Valparaíso: hazards and safeguarded areas.

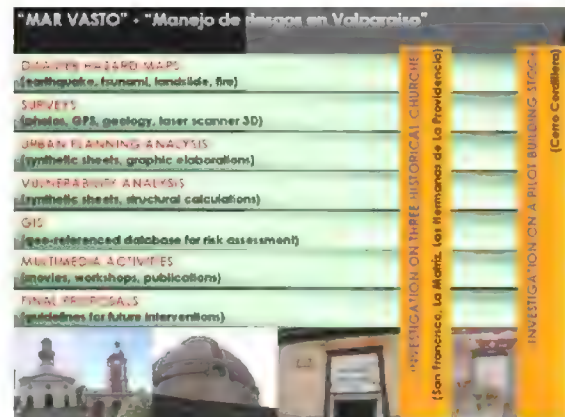


Figure 17. Brief description of the “MAR VASTO” Project.

### 3.3 The project architecture

The activities performed in the “MAR VASTO” Project are summarized in Figure 17: the horizontal lines refer to the “general purpose” activities, while targeted investigations are reported in the two columns. Being impossible to manage deep investigations for the entire Valparaíso historic area (due to limited financial resources and time), it was agreed with Chilean partners and stakeholders that the structures/areas to be investigated with the highest priority were (Fig. 18):

- a building stock in the Cerro Cordillera (partially included in the UNESCO zone);
- three important historical churches (“La Matriz”, “San Francisco del Barón”, “Las Hermanas de la Divina Providencia”), made of different materials and located in different city sites (according to the project objectives mentioned in Sect. 3.1).

### 3.4 The GIS database

The first “general purpose” activity consisted in the organization of a GIS geo-referenced database regarding the whole Valparaíso and building a detailed DEM (Digital Elevation Model) of the town area at ENEA, by generating ortho-photos from very helpful aerial photos provided by SHOA. Digital cartography (streets, buildings, quoted points and other information) provided by the Valparaíso Municipality often were not very accurate and didn't match the above said aerial photos. Therefore, a field survey using DGPS (Differential Global Positioning System) was carried out *in situ* (with a pattern of 33 points), in order to check the aerial photos and cartography, verifying the GIS database from the topographic point of view, removing uncertainties and clarifying univocally the real geographic position.

The GIS platform, organized in clear and user-friendly, maps a huge amount of data of general interest (aerial and satellite photos, cartography and topo-batimetry, GIS urban layers as buildings, open spaces and viability, geo-referenced historic maps, etc., see examples in Figure 19), but also information targeted on specific hazards and the building inventory of the Cerro Cordillera pilot study sector.

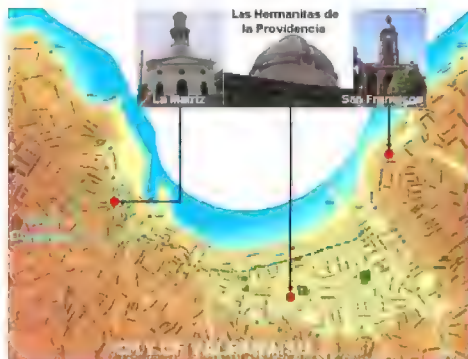


Figure 18. Location of the selected churches in Valparaíso.

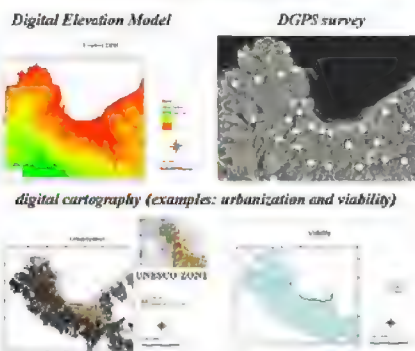


Figure 19. Organization of the GIS database for Valparaíso.



a) 1906 earthquake damage and Intensity



b) a centennial building surviving the 1906 earthquake

Figure 20. The Valparaíso 1906 earthquake.

### 3.5 Hazard maps

Hazard maps were developed for natural (earthquake, tsunami, landslide) and anthropic (fire) disasters and then stored in the GIS database.

Chile is one of the most earthquake-prone countries in the world; it was struck by the most powerful seismic event ever recorded (1960 Valdivia earthquake and tsunami). In particular, the 1906 event was the most destructive for Valparaíso (see Table 1 and Figure 20). Specific studies on seismic hazard were carried out. It is worth noting that the neo-deterministic approach [22] was used in the “MAR VASTO” project, in order to evaluate the seismic input in the Valparaíso area for certain earthquake scenarios (in general) and, in some sections, underneath the churches locations (in particular). In fact, case studies indicate the limits of the PSHA (Probabilistic Seismic Hazard Analysis) currently used methodologies, deeply rooted in engineering practice, which supply indications that can be useful but are frequently not sufficiently reliable. Four scenarios, taking into account two fault rupture typologies (unilateral and bilateral), were considered for the urban Valparaíso area (Table 2). The deterministic model was firstly checked on the 1985 seismic event available recordings; then it was extended to other scenarios, by obtaining synthetic time-histories (displacements, velocities and accelerations) for the two horizontal ground motion components (N-S e E-W) and a dense grid for the Valparaíso urban area, storing different 96 maps in the GIS database (an example is



shown in Figure 21). Specific seismic inputs, elaborated for the three churches sites, have been used in structural calculations to evaluate vulnerability and the effectiveness of strengthening interventions. In conclusion, it was confirmed that seismic hazard is very high in the Valparaíso urban area, not only concentrated in the flat zone along the coast (because of local amplification effects due to soft soil), but also widespread in the hills, for geologic/topographic configuration and structural vulnerability. Of course, secondary effects should also be foreseen (tsunamis, landslides, fire, etc).

Table 1. Strong earthquakes striking Valparaíso

date			location	M
year	month	day		
1647	05	13	Santiago, Chile	8.50
1730	07	08	Valparaíso, Chile	8.75
1822	11	19	Illapel and Chiloé, Chile	8.50
1906	08	17	Valparaíso, Chile	8.20
1965	03	28	Near Santiago, Chile	7.10
1971	07	09	Valparaíso Region, Chile	7.50
1985	03	03	Offshore Valparaíso, Chile	7.80

Table 2. Earthquakes scenarios for Valparaíso

M	Occurrence Period			
7.5 scenario event	occasional	≈ 120-140 years	strong	
7.8 1985 event	sporadic	≈ 200-250 years	very strong	
8.3 1906 event	rare	≈ 500 years	disastrous	
8.5 scenario event	exceptional	≈ 1000 years	catastrophic	

Table 3. Tsunami scenarios for Valparaíso

M	Occurrence Period			
7.0 scenario event	frequent	≈ 70-80 years	moderate/strong	
7.5 scenario event	occasional	≈ 120-140 years	strong	
7.8 1985 event	sporadic (*)	≈ 200-250 years	very strong	
8.3 1906 event	rare (*)	≈ 500 years	disastrous	
8.5 scenario event	exceptional	≈ 1000 years	catastrophic	

(\*) From SHOA source models and simulations

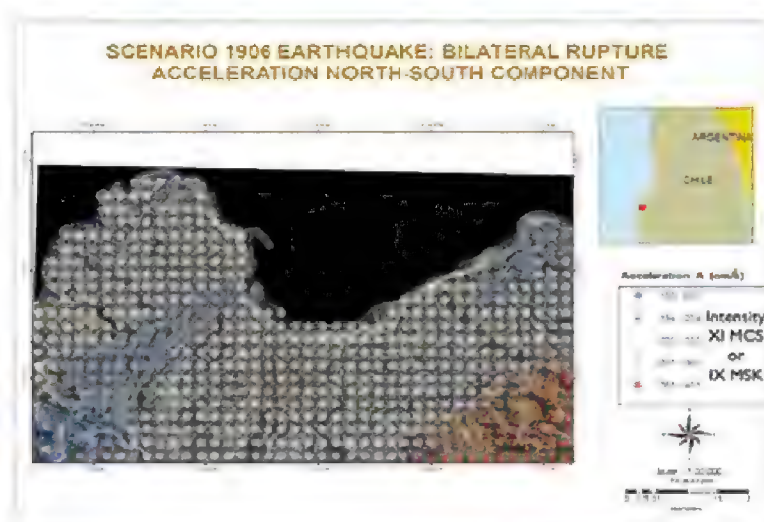


Figure 21. Example of grid map for earthquake scenarios.

Inundations occurred several times in the past (Fig. 22). Starting from source models and simulations (1985 and 1906) studied by SHOA, a dataset of tsunami signals (including tsunamigenic parametric studies) was computed, using analytical techniques [23], for different scenario earthquakes (see Table 3) to complement the assessment of the tsunami hazard at Valparaíso. Then, inundation maps were implemented (Fig. 23), defining a relationship between the sea wave maximum height and the amplification in comparison with the reference earthquake event (1985). It is clear that the entire coastal line in the Valparaíso harbor zone must be considered at high risk of flooding.



Figure 22. Old picture showing an inundation in Valparaíso.

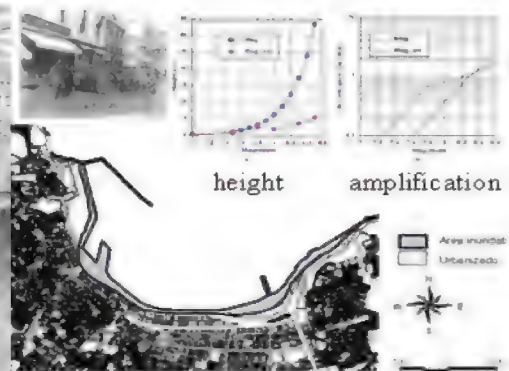


Figure 23. Tsunami inundation map.

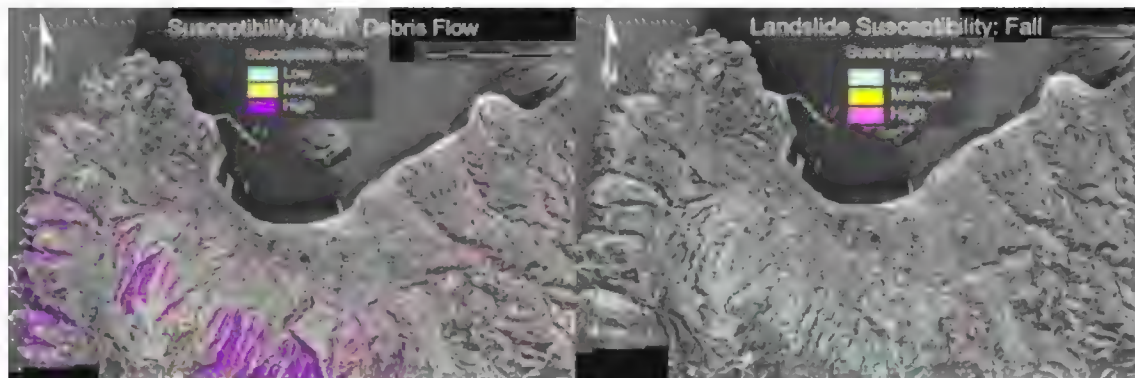


Figure 24. Landslide susceptibility maps.

Slope, landslide inventory and susceptibility maps (Fig. 24) were provided through in-field campaign, reconstruction of past landslide events from historic archives, pluviometric analysis and digital/analogical aerial photos elaboration. Landslide hazard is very high in the entire Valparaíso amphitheatre. The upstream hill side is mainly characterized by mud-debris flow events, triggering a couple of times in the year, concentrated in the summer season. The intensity of these phenomena can vary widely, but the presence of densely populated urban settlements in ravine beds, escarpment sides and valley heads (often artificially terraced) makes the associated risk very high. The coastal flat is reached by moved materials only when the event is intense or when several activated areas merge and flow together in the same bed. Fall events are punctual and characterized by local effects, but often destructive, at the basis of the sub-vertical sides. Certainly, seismic ground shaking as cause of landslide phenomena should be carefully investigated.

Fires are the most frequent and dangerous Valparaíso disasters. The “state-of-the-art” information was provided by Firemen Corp and Valparaíso Municipality, with particular regard to the Calle Serrano tragedy. In fact, on February 3, 2007, a violent explosion due to a gas leak killed four people, destroyed some heritage buildings and damaged others in Calle Serrano, in the core of the UNESCO zone. Despite the good expertise of local Firemen, fires occur in the urban area (due to bad maintenance of electric systems and gas pipelines, building materials, lack of education and vandalism), but also in the surroundings forests and bushes (the latter are mainly events of anthropic origin). The risk is worsened by usual windy weather, narrow and tortuous hill roads, presence of wooden houses and, sometimes, insufficient water pressure in the hydrants. Also the presence of the close harbor facilities represents a further risk factor. Moreover, important monuments not only burned during the 1906 earthquake, but were also damaged by recent fires (like the Church of “San Francisco del Barón” in 1983). Figure 25 shows the hazard map, marking the most Valparaíso fire-prone locations. Our results were confirmed by a couple of recent fire events: they occurred exactly in one of the most prone areas identified in the GIS database.



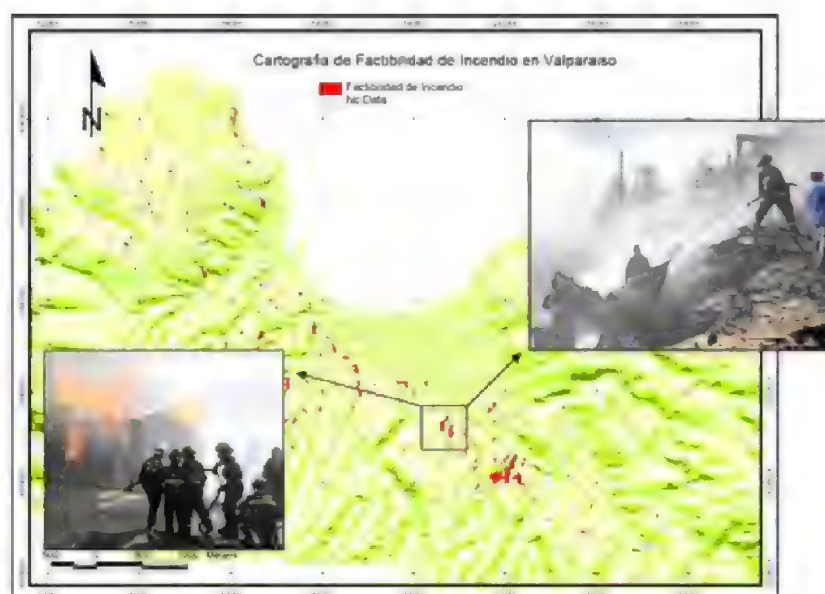


Figure 25. Fire hazard map for Valparaíso.

### 3.6 The Cerro Cordillera investigation

Geo-referred hazard maps must interact with a detailed land and building inventory, in which urban planning and single construction features (architecture, structural characteristics, vulnerability, present status, etc.) are linked to the surrounding environmental and social context.

The pilot zone of the Cerro Cordillera is an historically “virgin”, socially complicated and poor sector, partially inside the UNESCO area, delimited by Calle Serrano (plan side), the San Agustín cable car upper station (hill side) and the two opposite ravines of San Francisco and San Agustín (Fig. 26).

The architectonic/urban planning investigation concerned 230 constructions, 4 public areas and about 50 road network stretches. The information (function, architectonic style, general condition, etc., see Figure 26a) was picked up through *in situ* surveys (using an investigation form specifically studied for Valparaíso), then stored in the GIS. Different indexes properly overlapped (for example, high architectonic quality and bad conditions) enabled the identification of rehabilitation priorities.

Based on the above work, earthquake vulnerability investigation were carried out for 70 structures (Fig. 26b), when exhaustive cadastral data were available (plans, prospects, sections, construction details, geotechnical features, etc.), excluding informal and illegal houses. A special form has been elaborated for Valparaíso, upon Italian established procedures [24]. Almost half of the analyzed units showed a high vulnerability index  $I_v$  (Fig. 26b).

### 3.7 The investigation on churches

The three important churches mentioned in Sect. 3.3 (Fig 27) were investigated thanks to Church Authorities and Valparaíso Firemen. For them the following steps carried out: historic data collection; laser scanner/photographic survey, visual investigation and evaluation of maintenance and damage; vulnerability evaluation; execution of preliminary numerical calculations, if necessary; indication of rehabilitation actions. Vulnerability was evaluated using a well known Italian procedure, by completing specific survey forms conceived for churches [25].

Periodically destroyed by earthquakes, tsunamis and fires, the present fourth version of La Matriz Church was constructed from 1837 to 1842 (with modifications after 1897), in the same place of the original first chapel, built in the ancient nucleus of the “Puerto” after the discovery of the Valparaíso Bay in 1559. The church, in simple neoclassic style, is made of adobe perimetral walls and a masonry façade, with a roof of clay tiles. The bell-tower, modified at the end of the XIX century, is wooden and presents an iron spiral staircase inside. The internal colonnades, forming the naves, are also wooden. In the XX century a certain damage occurred, due to seismic activity, scarce maintenance and termite attacks. Partial interventions took place between 1971 and 1988. The most relevant damage mechanism is due to in-plane shear actions in the façade, but the global vulnerability index is about 8%, which is a very low value. In conclusion, “La Matriz” can be considered in sufficiently good static conditions, but a general restoration is anyway suggested, for fire, materials degradation and termite attacks prevention.

The neo-baroque tower and façade of the San Francisco del Barón Church were erected in 1890-92, thanks to the project of architect Eduardo Provasoli. This church consists of brick masonry connected by lime. It faced four earthquakes (including those of 1906 and 1985) without collapse, but a severe damage was found mainly in the bell-tower and the arcades during the investigation. The construction seems to be (in the façade and in the bell-tower) a

very regular masonry brickwork, but diagnostics testing is strongly recommended. The building shows heavy widespread structural damage and lack of effective antiseismic protections. The most relevant damage/failure mechanisms are out-of-plane façade overturning and collapse of the bell-tower. The global damage index is 33%, but the local damage index in the façade (66%) is very high. The present damage situation must be considered very worrying, because partial or total collapse (especially in the bell-tower and in the façade) can occur in case of significant earthquakes (i.e. medium to high magnitude seismic excitations, as expected in the Valparaíso area); in fact, the church is unsafe and must be urgently closed partially or totally, by planning both prompt safety measures and overall strengthening as soon as possible. After several technical meetings with the Regional and Church Authorities, a Chilean-Italian team prepared a proposal for a prompt intervention, to be performed as an exploitation of the “MAR VASTO” project cooperation.

a) architectonic/urban planning analysis



b) vulnerability analysis

vulnerability index	vulnerability level	percentage in the stock
$0 < I_v < 30$	low	22%
$30 < I_v < 45$	average	20%
$45 < I_v < 60$	high	16%
$60 < I_v < 100$	very high	42%

Figure 26. Investigation in the Cerro Cordillera.



Figure 27. Survey on churches (La Matriz, Hermanas, San Francisco).

With regard to “Las Hermanas de la Divina Providencia” Church, the homonymous congregation erected a first chapel, which underwent various modifications until the fire of 1880, in the “Puerto”, after 1867. Then, a second version was built on the Merced Hill (1880-1883), but this collapsed almost completely during the 1906 earthquake and was later demolished. The construction of the present building (designed by the architect Victor Auclair in a neo-renaissance style, but made of a rare primitive r.c.) began in 1907. It is located in the Almendral at the Merced foothill, exactly where the 1906 earthquake reached the highest Intensity value (X). The church was severely damaged by the 1985 earthquake, declared unsafe and almost completely closed, without any rehabilitation. This monument is characterized by a lot of critical parameters (façade tympanum overturning, in-plane shear mechanism in the façade, transversal response of nave and transept, collapse of the dome, apse overturning, apse and presbytery vaults rupture and wall shear rupture). The global vulnerability index is 58%. The present damage situation must be considered very worrying, because partial or total collapse (in several structural parts, due to widespread weakness) can occur in case of the violent earthquakes expected in the Valparaíso area. Due to the particular typology of the construction materials (as mentioned, a primitive r.c. very rare in the world), a strengthening intervention with conventional techniques can be ineffective or very invasive; a solution should be planned only after a detailed design work. As a suggestion, in order to drastically reduce the seismic input, the possibility of installing a base isolation system may be explored (with all the due precaution and by avoiding elevation and foundation wall cutting, thanks to the insertion of a sub-foundation): this solution (see Sect. 4) seems possible, also due to the apparent absence of crypts.

## 4 MODERN ANTISEISMIC TECHNIQUES

### 4.1 Seismic Isolation

The design with SI or ED aims at drastically reducing the seismic forces acting on the structure, rather than relying on its strength [19]. More precisely, when applied to buildings, SI makes their movement independent from that of the ground, usually only in the horizontal plane: it decouples the motion of the foundations from that of the ground, by “filtering out” at least the horizontal components of the earthquake, which are the most dangerous. This type of approach is pursued by inserting devices (isolators) usually at the base of the building or at its lowest floor; the isolators are laterally very flexible (in the case of steel-laminated rubber bearings) or are sliding or rolling devices.



In the floors above those where the isolators are incorporated, the structure (if not too flexible) moves quasi-rigidly in the horizontal plane, with very small values of both accelerations and inter-storey drifts, therefore safeguarding not only the structural parts but also the non-structural ones (claddings, partitions and all other building contents). In particular, the “superstructure” (i.e. the part of the structure supported by the isolators) benefits from a drastic reduction of the values of accelerations, their vertical variations and horizontal deformations; a circumstance which cannot absolutely occur in a building with conventional foundations. In fact, the fundamental period of the construction increases considerably thanks to SI, thus accelerations decrease significantly. In parallel, its transverse displacements increase considerably, but when SI is applied, these are deformations that are practically all concentrated in the isolators.

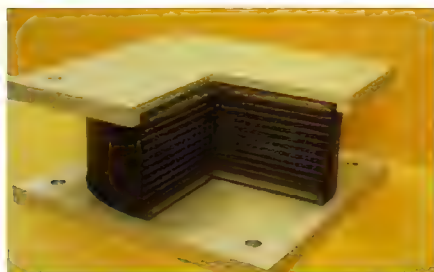


Figure 28. Internals of a High Damping Rubber Bearing (HDRB), showing the steel laminations inserted in the rubber.

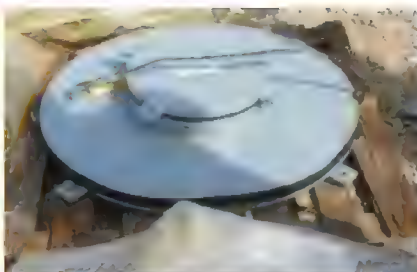


Figure 29. A SD of the SI system of the new Francesco Jovine school buildings at San Giuliano di Puglia (Italy).

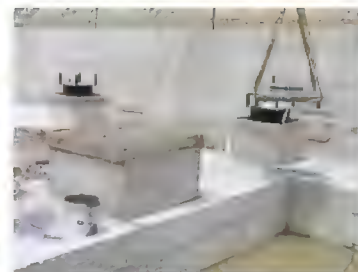


Figure 30. A SD during its installation below the “artificial ground” slab supporting the buildings of Fig. 29.

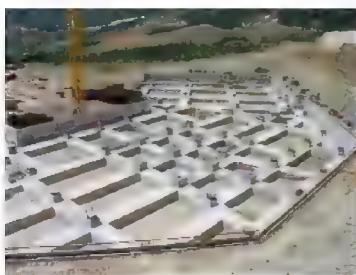


Figure 31. The 61 HDRBs and 12 SDs installed below the “artificial ground” slab supporting the buildings of in Fig. 29.

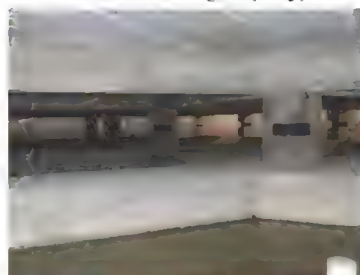


Figure 32. The SI system installed at the base of the building of Fig. 29. Safety was certified by A. Martelli in September 2008.



Figure 33. A “steel sphere recirculation” isolator, used to protect several Japanese cottages, together with VD's (see later) and re-centring devices.

Although the main function of the SI system is to filter out the seismic energy, it must have sufficient dissipation capability, so as to limit the maximum design displacement to acceptable values (usually 10 to 45 cm in Italy, but up to the 80-100 cm typical of areas with very high seismic hazard, such as California and Japan). This, in turn, requires a reliable estimate of the ground displacement due to the earthquake. Since good data related to such displacements are very scarce, a very useful way to get reliable estimates is to turn to the direct realistic modeling of displacement. This procedure should flank, if not replace, the common but very hazardous practice, not justified by any physical law, of transforming response spectra determined using records of acceleration into displacements in a straightforward way. When using Rubber Bearings (RBs) as isolators, dissipation is achieved by mixing additives (special oils and resins) to the rubber compound (High Damping Rubber Bearings – HDRBs, see Figure 28), or, if it is necessary to obtain damping values larger than 15% (those achievable by the HDRBs), by inserting lead plugs (Lead Rubber Bearings – LRBs) or silicone fluids inside the isolators. It is also possible to install some dampers in parallel to the RBs (this solution is often adopted in Japan).

Besides being characterized by the primary and secondary functions just described, an adequate SI system must have a good ability to bring the structure back to its original position after the earthquake (“re-centering”), a long useful life (at least equal to that of the structure, although the possibility of replacing the isolators, if and when necessary, shall be usually ensured), a horizontal stiffness decreasing by increasing vibration level (high for small excitations, to prevent continuous vibrations due, for example, to wind), stiffness and damping not significantly sensitive to the effects of temperature changes and ageing, etc. The RBs that are manufactured nowadays possess all these features. However, other SI devices, such as Sliding Devices (SDs), usually made of superposed steel and Teflon (PTFE) surfaces, are currently used (Fig. 29). In some designs – such as those at first used in Japan and recently in Italy, too – SDs have been coupled to RBs (Figs. 30-32). The whole system (RBs + SDs) has the necessary re-centering capability. SDs are very useful support buildings or parts of them that do not bear large vertical loads. These isolators (in conjunction with dampers and re-centering devices) have also proven to be economically valid to efficiently isolate even small houses and light equipment or other objects, including those concerning the cultural heritage.

For protecting both heavy and light structures, “rolling” devices (e.g. the steel sphere isolators shown by Figure 33) are also efficient. Finally, there are already numerous important applications, in the world, of the “Friction Pendulum System” (FPS), developed in the USA, or of devices recently derived from its improvement (Fig. 34), like the German and Italian Sliding Isolation Pendulum (SIP) isolators: a large application of the latter is being

completed at L'Aquila (January 2010), in the framework of the construction of 184 prefabricated houses for the people who remained homeless after the Abruzzo earthquake of April 6, 2009 [26-27]. The advantage of the “rolling”, FPS and SIP isolators is that the fundamental period of the superstructure is nearly independent of the mass: thus, they may be used to protect both heavy and light structures. The “sliding” and “rolling” principles for seismic protection are based on old design approaches, which were the first proposed achievements and applications of SI in the past, up to the early XIX century [9-10, 16, 18]. However, the “rolling” isolators which are available to date are rather costly and need to be installed in parallel to damping and re-centering devices, while the FPS and SIP ones are rather delicate and require for an accurate protection from dust and humidity during the entire service life [26].



Figure 34. Left: SIP isolator during its installation in Greece, at the Acropolis Museum base in the Onassis Centre at Athens (Fig. 63). Right: sketch of the ALGAP-END isolators, which were installed in the Golden Ear Bridge in Canada in 2007.

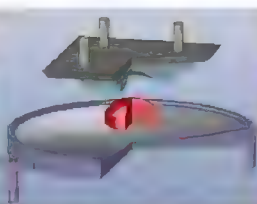
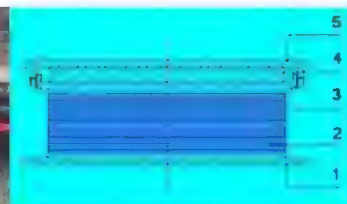


Figure 35. 3D HDRBs used to isolate buildings erected above the Beijing underground main station in the People's Republic of China (1= lower plate; 2= horizontal steel laminated isolator; 3= intermediate plate; 4= vertical isolator; 5= upper plate).



SI is usually applied only in the horizontal plane because the vertical component of the earthquake is usually less violent than the horizontal ones (at least outside the epicentral area) and also because the structures – for their construction features – are much more resistant to the vertical vibrations than to the horizontal ones (they shall bear their weight).

The use of three-directional (3D) SI devices introduces the difficulty of controlling rocking, although some applications of such devices have already been performed in both Japan and the People's Republic of China (in particular to isolate both seismic vibrations and those caused by traffic – see Figure 35) and specific “anti-rocking systems” to be used in nuclear installations were recently developed in Japan. In general, when it is necessary to protect equipment or other particularly sensitive items (for example, computers, other seismically vulnerable electronic equipment or materials, art objects, or safety-related components of nuclear facilities), it is usually easier to horizontally isolate the base of the building that contains them and to vertically isolate only the floors of interest, or the single objects themselves, or (in the case of nuclear plants) only the reactor block (which contains the core and other seismically risky components).

SI is a technique that is easily enforceable in the case of buildings or other structures of new construction, but it can also be used for the retrofit of already existing structures: in this case, SI is usually obtained for buildings through cuts of the foundations or load-bearing structures (columns and walls) positioned at the lower floor, or by excavating a new underground floor and inserting the isolators there (SI in “sub-foundation” – see, for instance, Figure 36). Retrofit with SI has already been often successfully used, at first in New Zealand and the USA and now also in Italy, Japan, Armenia, the People's Republic of China, the Russian Federation, Turkey, etc. With regard to sub-foundation, it is worthwhile stressing that its creation is an indispensable condition in countries like Italy for the retrofit of historic buildings by means of SI: in fact, according to the conservation requirements in force in this country, cuts of foundations or other structural elements (as frequently done for such buildings in some other countries, although for constructions which are rather less old than many of the Italian ones, see, for instance, Figures 37-39) is not permitted.

The application of SI is particularly advantageous for buildings that have substantial asymmetries in the horizontal plane and/or elevation. In fact, these asymmetries are very problematic, in significantly seismic areas, for the conventional non-isolated buildings: in particular, those in the horizontal plane generate dangerous torsion effects. For the non-isolated buildings, in order to avoid significant geometric asymmetry in the horizontal plane or in elevation, it is frequently necessary to separate them into several sub-buildings that are sufficiently symmetrical. This is usually unnecessary for the isolated constructions, because the almost rigid movement of the superstructure minimizes the negative effects of the asymmetries in elevation and an appropriate spatial distribution of the RBs – if necessary together with different values of their stiffness (obtained by using different diameters and/or different values of the rubber shear modulus) and even the insertion of some SDs (Figs. 29-32) – in general allows to bring the centre of stiffness of the SI system to coincide, or nearly, with the projection of the centre of gravity of the building on the SI axial level. This is the condition which prevents the harmful torsion stresses.

With regard to Italy, the new seismic code that was enforced in May 2003 (and became of obligatory use during Summer 2009, thanks to the new Technical Norms for Constructions), besides authorizing the free use of the anti-seismic systems and devices, has made them much more economically advantageous. In fact, it allows to partially take into account the reduction of seismic forces acting on the superstructure and foundations which is caused by SI and to assume constant (instead of increasing) acceleration of the superstructure from base to top, in line with its quasi rigid-body movement. The projects developed by referring to the new Italian code show that these simplifications significantly reduce and often cancel the additional construction costs related to SI (i.e. SI system,



possible additional floor, ground retaining wall, etc.), for both new and existing buildings, since these costs are at least partly balanced by savings deriving from the significant reduction of the superstructure and foundations weight and reinforcing (in some cases even considerable savings are possible). However, even where the additional construction costs are not fully balanced, two major benefits remain in favor of SI: not only the much larger safety (which should be the main purpose of the design), but also the much better overall economic balance, which correctly also takes into account the costs to be addressed after a possible earthquake (repair or demolition, rebuilding, etc.).



Figure 36. Private house at Fabriano (Ancona, Italy), seismic zone 2, damaged by the 1997-98 Marche and Umbria earthquake, then retrofitted by sub-founding it and inserting 56 HDRBs in the new underground floor (right). The safety of this house was certified by A. Martelli in 2006.

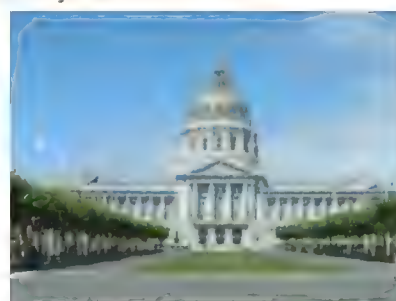


Figure 37. Left: the Salt Lake City & County Building (1894), retrofitted with 447 LRBs and LDRBs in 1989, after having been damaged in a severe quake. Right: San Francisco City Hall (USA), destroyed by the 1906 earthquake, reconstructed in 1912, again severely damaged by the 1989 Loma Prieta earthquake and retrofitted with 530 LRBs and 62 SDs in 2000.

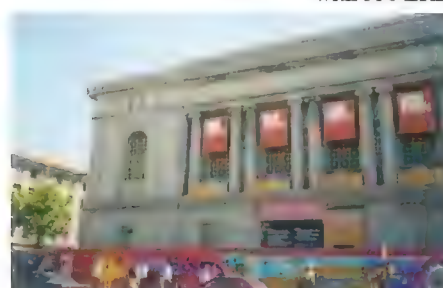


Figure 38. The Asian Art Museum at San Francisco (USA), retrofitted with RBs in the years 2000s, by cutting the foundation walls and columns for inserting the isolators.

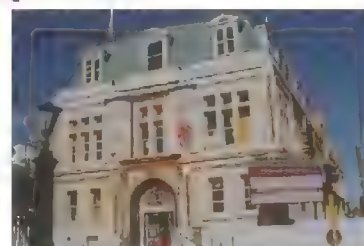


Figure 39. Left: the Wellington Parliament, built in 1921 and retrofitted with LRBs in 1992-93. Right: the Maritime Museum at Auckland (New Zealand), retrofitted with LRBs in 1993.

Obviously, the condition under which this conclusion applies is that the SI devices are adequately selected, qualified, manufactured, installed, protected and subjected to the necessary inspections and maintenance: otherwise, in Italy and the countries where the seismic code has features similar to those of the aforesaid Italian one, the seismically isolated buildings would be less safe than the corresponding ones with conventional foundations [26, 27].

## 4.2 Energy dissipation

ED is obtained by inserting suitable devices, called “dampers”, in special positions of the structure (for a civil building usually on the diagonals between adjacent floors, where the differential displacements between the two floors are maximum – see Figures 40-43), which are capable to “attract” and concentrate on themselves the dissipation of a large part of the energy transmitted by the earthquake to the structure, namely to transform this energy into heat [26]. In absence of dampers, the transformation of energy into heat is performed by the structural and non-structural elements through their damage and even the collapse of the construction or parts of it.

The most common Dampers are Elastic-Plastic (EPDs), Viscous (VDs), Visco-Elastic (VEDs), based on Friction (FDs), or Electro-Inductive (EIDs). Nowadays, Buckling Restrained Braces (BRBs), which consist of steel bars inside concrete shells (preventing buckling of the bars in their compression phase), are also very popular for protecting both new and existing buildings. The EPDs (Figs. 40-41) base their performance on the capability of special steels and other materials to withstand several cycles of high plastic deformation (thus, their ED is mainly displacement-dependent), while for VDs (Fig. 42) the ED results from the passage of a highly viscous fluid (for example, a silicon fluid) through narrow openings in the septum that is present in a piston-cylinder system (thus, their ED is mainly velocity-dependent). The VEDs (Fig. 43), which make use of very dissipating rubber sheets, have an intermediate behavior (ED is both displacement- and velocity-dependent). For buildings, ED systems are less effective than the SI ones, because, to be able to work, they need that the structure undergoes some deformation and, therefore, they cannot reduce the inter-storey drifts to the same extent as SI can do. Moreover, by not increasing the fundamental vibration period of the structure, the ED systems do not minimize panic to the same extent as SI. Finally, they often require the installation in buildings of items that are bulky and often unaesthetic, namely the dampers themselves and the braces that are indispensable to rigidly transmit, to the floor at which the dampers are installed, the displacement of that located below or above it (Fig. 13). Thus, for several historic buildings, the installation of dampers is hardly compatible with the conservation requirements. This technique, however, is particularly useful when SI is not applicable or is hardly applicable. This occurs when:

- the building under consideration is too flexible (e.g., in the authors opinion, for very high-rise modern buildings, in spite of several Japanese and some Russian applications of this kind);
- the building walls are not structurally connected to one another (as for many historic buildings, in particular churches);
- the soil on which the building rests is too soft;
- it is necessary to seismically retrofit a building that is not sufficiently distant from the adjacent ones (and it is not possible to create the necessary distance).

With regard to the latter situation, we note that the aforesaid distance shall be such as to allow for excavating the lateral structural gap which is indispensable not to hinder the free rigid-body displacements of the superstructure during the design earthquakes (it was previously mentioned that these displacements may reach some tens of centimeters).

## 4.3 Shock Transmitter Units and Shape Memory Alloy Devices

The so called Shock Transmitter Units (STUs) are oleo-dynamic provisional restraints which let the structure free to move under slow deformations, like the thermal ones, but (similar to the safety belts of cars) jam, so stiffening the structure, if the deformations are rapid, such as those caused by significant earthquakes (Fig. 44) or (for bridges and viaducts) by suddenly braking trucks.

The Shape Memory Alloy Devices (SMADs) allow to join, during an earthquake, structural elements that are disconnected and may be subjected to considerable relative displacements, by strongly limiting (if adequately pre-stressed) the variations of the loads acting on such elements (Figs. 45, 47-52). This behavior is a consequence of subsequent phase transitions between the austenitic and martensitic crystalline states that SMA materials undergo during an earthquake, if the wires forming the devices are pre-stressed in such a way that their initial deformation lies in the upper flat part of the hysteresis cycle [13, 28]. It is also noted that, since SMADs work thanks to a phase transition (not to cycling in the plastic field, as the EPDs do), their crystalline structure does not suffer any damage during an earthquake, thus they are fully re-centering devices (contrary to the EPDs).





Figure 40. The Domiziano Viola (left) and Giacomo Leopardi (right) schools at Potenza (Italy), seismic zone 1, retrofitted with dissipative braces incorporating EPDs at their top in 2000 and (respectively) 2004.



Figure 41. An EPD installed on the roof of the Santa Maria di Collemaggio Cathedral at L'Aquila, Italy (Fig. 53).



Figure 42. One of the re-centring VDs installed in the Dome of Siena (Italy), during the acceptance tests (Fig. 54).



Figure 43. Left, the Gentile Fermi school at Fabriano (rationalist architecture, thus considered as a cultural heritage building), retrofitted with braces incorporating VEDs and internal strengthening in 2000, after having been damaged by the 1997-98 Marche and Umbria earthquake (it also had serious static problems prior to the earthquake). Right: one of the aforesaid VEDs (these VEDs and the braces incorporating them are much less bulky than the EPDs of Fig. 40).

The first and nowadays most numerous applications of STUs concern bridges and viaducts (where they are coupled to other anti-seismic devices) and some industrial buildings, but there are also some important examples of their use in historic buildings, at least in Italy (Figs. 44 and 46). On the contrary, SMADs (which are still rather costly) were specifically developed for the protection of cultural heritage: in Europe this was made in the framework of projects (ISTECH, MANSIDE, etc.) partly funded by the European Commission (EC). It is noted that, thanks to their features, SMADs may also be used for re-centering dampers: an application of this kind is already available in Italy (Fig. 59).



Figure 44. Two STUs inserted inside the Upper Basilica of St. Francis at Assisi during its retrofit in 1999 and their location.



Figure 45. Up: transept roof of the Upper Basilica of St. Francis at Assisi after the installation of 47 SMADs between it and each tympanum during the retrofit in 1999. Down: internals of one of the aforesaid SMADs.



Figure 46. Left: some of 18 STUs installed on the roof of the San Giovanni in Carife Church in 1990. Right: one of the 24 STUs installed on the roof of the New Library of the University of Naples "Federico II" (together with 34 neoprene bearings – NBs) in 1996.

#### 4.4 Application in Italy

In Italy, the first two modern applications of anti-seismic devices to monumental buildings date back to 1990 and 1996 and are due to Prof. F. Mazzolani of the Naples University "Federico II": they concerned the rehabilitation of the Church of San Giovanni Battista in Carife, near Avellino, and, respectively, that of the new Library of the Naples University "Federico II", where STUs were installed in the new roof structures, so as to stiffen them during an earthquake (Fig. 46). Later, SMADs, developed in the EC-funded ISTECH Project, were used for the first time in the world for the seismic protection of cultural heritage. The first application concerned the Upper Basilica of St. Francis at Assisi in 1999 (Fig. 47), where, in the framework of its restoration after the heavy damages caused by the 1997-98 Marche and Umbria earthquake, 47 SMADs were used to connect both tympana to the transept roof without overloading the masonry, together with 34 STUs (developed in the EC-funded REEDS Project), which were installed along the internal perimeter of the Basilica building (Figs. 44-45). Shortly afterwards, in the framework of the aforesaid ISTECH Project, 4 SMADs were also used, in series to four ties, for rehabilitating the bell tower of the San Giorgio in Trignano Church (San Martino in Rio, Reggio Emilia), which had been cut into two pieces (luckily remained superposed) by the 1996 Reggio Emilia and Modena earthquake (Fig. 48), and, somewhat later (Figs. 49-52), for seismically improving further churches that had been damaged by the 1997-98 Marche and Umbria earthquake (the Cathedral of San Feliciano at Foligno and the Church of San Serafino at Montegranaro) or by other seismic events, like the Church of San Pietro in Feletto, near Treviso [28-29]. Finally, more recent applications of SMADs and STUs concern the rehabilitation of the bell tower of the Badia Fiorentina in Florence (Fig. 52) and, respectively, that of the MAXXI Museum in Rome.

With regard to the application of ED systems, to be cited are that of EPDs installed in the roof of the Cathedral of Santa Maria di Collemaggio at L'Aquila (Figs. 41 and 53) and, more recently, that of re-centering VDs to restrain the façade of the Siena Dome (Figs. 42 and 54). The Cathedral of Santa Maria di Collemaggio suffered heavy damage during the Abruzzo earthquake of April 6, 2009, with the collapse of the roof in its baroque (not yet retrofitted) part, but the façade, which had already been protected by some of the aforesaid EPDs, survived the earthquake (however, a steel scaffold, previously erected for an already planned retrofit, certainly helped) [27].

Finally, as far as the application of SI to the monumental buildings is concerned, none exists yet in Italy, contrary to countries like the USA and New Zealand (where, however, such buildings are only a couple of centuries old): in fact, as mentioned, this kind of rehabilitation is quite costly and delicate in Italy, because the conservation



requirements do not allow for any cut of foundations in this country and, thus, SI requires the creation of a sub-foundation, where to install the isolators. However, two pilot projects have already been developed, for the Umbrian Churches of San Giovanni Battista at Apagni, near Sellano [30], and Santa Croce at Casematte, near Nocera Umbra (both located in the Perugia Province), which had been severely damaged by the 1997-98 earthquake and, previously, by the 1979 Valnerina event, by stressing the limits of conventional restoration (Figs. 55 and 56). These projects were approved some years ago, but the necessary funding has not yet been made available.

While the use of SI is rather problematic for the existing monumental structures, it is easy and highly recommended for new structures hosting art objects, such as new museum, and for ceilings protecting archaeological excavations. Several seismically isolated museums, both new and retrofitted, already exist in other countries, but, unfortunately, none in Italy (the only Italian museum protected by anti-seismic systems that is known to the authors is the already mentioned MAXXI Museum in Rome, where STUs have been installed).

However, SI has already been used in Italy to protect the new centre for conservation of cultural heritage erected at Spoleto (Perugia) and is being adopted for a building of the new Civil Defense Centre of Foligno (Perugia), seismic zone 1, which will host paintings and statues taken from buildings damaged by future natural catastrophic events.

Furthermore, SI has also already been used in Italy to protect some unique masterpieces. In particular, the Bronzes of Riace at the Museum of Reggio Calabria, the bronze statue of Germanicus Emperor at the National Museum of Perugia and the Dancing Satyr of Mazara del Vallo have been seismically isolated by means of 3-stage HDRB systems (Figs. 57 and 58), while the original marble statues of Scylla and Neptune at the Museum of Messina are supported by a SI system formed by steel-PTFE SDs and SMADs (Fig. 59). In addition, 3D isolators, developed in the framework of the EC-funded SPACE Project, were recently installed in the Ercolano Museum to protect a wooden Roman ship [31] excavated in that area (Fig. 60) and steel sphere isolators have already been used to protect display cases in the Assisi Museum.



Figure 47. Left: the tympanum of the Upper Basilica of St. Francis at Assisi which was the most severely damaged by the 1997-98 Marche and Umbria earthquake. Right: the aforesaid Basilica after its restoration in 1999.



Figure 48. Bell tower of the San Giorgio in Trignano Church at san Martino in Rio (Reggio Emilia), retrofitted using 4 SMDs in 1999.

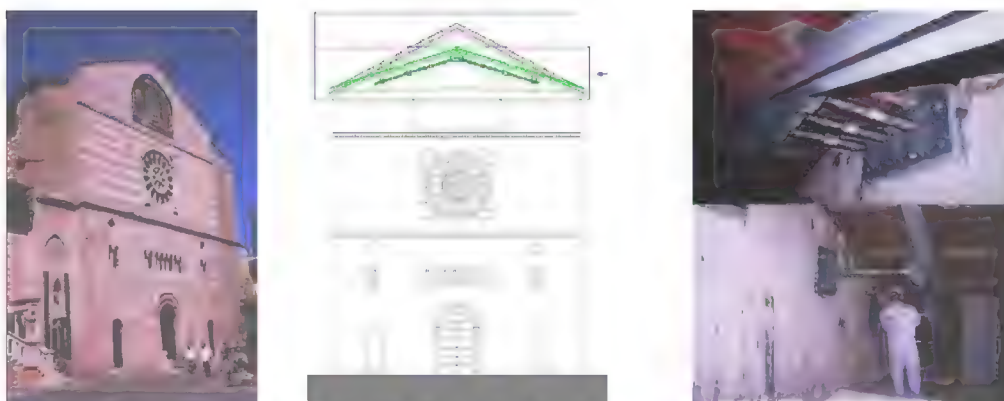


Figure 49. The façade of San Feliciano Cathedral at Foligno (Perugia), retrofitted with SMDs and view of some of these.



Figure 50. The San Pietro in Feletto Church, retrofitted with SMADs.



Figure 51. Two SMADs installed in the roof of the San Serafino at Montegrano Church.



Fig. 52. The Badia Forentina (Florence), improved with 18 SMADs in series to ties in 2006.

#### 4.5 Application in Other countries

Numerous further countries are already very active on the use of anti-seismic systems to protect cultural heritage [32]. As far as retrofits of historical buildings are concerned, in addition to those performed by means of SI in the USA and New Zealand (Figs. 37-39), some recent applications of the anti-seismic systems in the Russian Federation are rather interesting (Fig. 61).

For the protection of art objects, it is worthwhile mentioning that numerous seismically isolated museums, both new and retrofitted, already exist in Japan, the USA, the People's Republic of China, New Zealand, Greece and other countries (see, for instance, Figures 38-39 and 62-64). Among those retrofitted, the Le Corbusier Museum in Tokyo (Fig. 64) shall be stressed; in fact, a sub-foundation was excavated to install the SI devices, because (due to its renowned designer) the building was considered as part of cultural heritage, although it was not an old construction. Of note is also the design of retrofit with SI of the Iran Bastan Museum in Tehran (Fig. 65), being developed in the framework of a collaboration between Italy and Iran [32]. In addition, to be cited is the protection of the archaeological excavations at Akrotiri (in the Greek Santorini island) through SI of its ceiling by means of LRBs and SDs, which, by the way, were manufactured in Italy (Fig. 66).

With regard to very old structures, we cite the retrofit with SI of the "Daigokuden" at Nara, in Japan (Fig. 64) and the project of displacement and SI of the small Chapel of St. Cathoghikch at Yerevan, a symbol of the Armenian religion, now hidden by ugly Soviet buildings (Fig. 67).

Finally, as far as the protection of single art objects in countries other than Italy is concerned, we cite:



- some monuments and statues, like the “Gates of Hell” (Fig. 68), located just in front of the Le Corbusier Museum in Tokyo, and some Chinese applications (see, for, instance, Figure 69);
- the seismically isolated display cases existing for several years in some countries, for instance at the Santa Monica Museum in California (USA), in Japanese museums (Fig. 70), etc.



Figure 53. Santa Maria di Collemaggio Cathedral at L'Aquila, an unique example of Abruzzo Romanic style (partly destroyed by a violent earthquake, then reconstructed in baroque style and finally returned to its original style), which was retrofitted by installing EPDs on the roof (Fig. 41), also because it had considerably vibrated during the 1997-98 Marche and Umbria earthquake (in spite of the large distance from the epicentre).

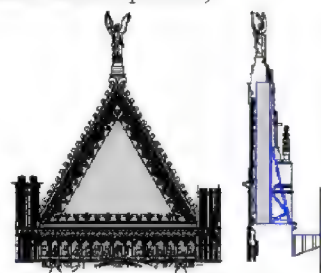
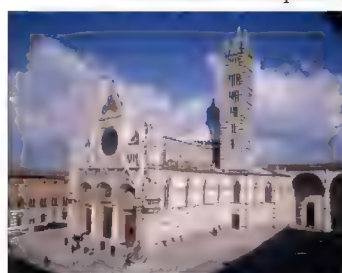


Figure 54. Seismic improvement of the Dome of Siena, performed by means of re-centring VDs (Fig. 15) to avoid overturning of the façade.



Figure 55. The San Giovanni Battista Church at Apagni, as damaged after the first shocks of 1997-98 Marche and Umbria earthquake (it contains paintings of the Giotto school)

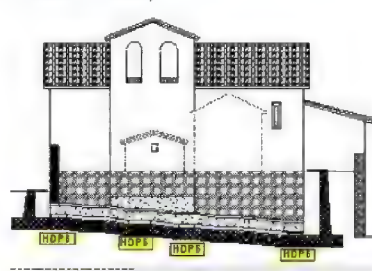


Figure 56. Left: the San Giovanni Battista Church after its conventional restoration in 2000. Right: its SI design, with a system formed by 8 HDRBs and 6 SDs to be installed in a sub-foundation.



Figure 57. The Bronzes of Riace, the first Italian masterpieces protected by SI (years '90s) and the 3-stage HDRB system used (to avoid instability of too tall single HDRBs) that is hidden inside the pedestal.

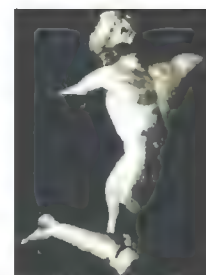


Figure 58. The bronze statues of the Germanicus Emperor (left) and the Satyr of Mazara del Vallo (right), which were isolated using 3-stage HDRB systems similar to that of Figure 29.

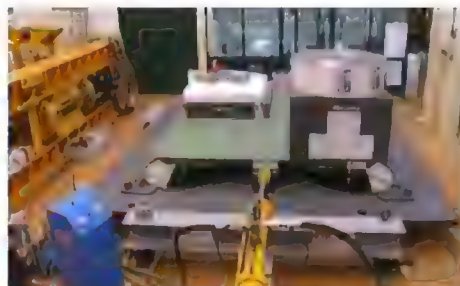


Figure 59. The original statue of Scylla, a copy of the entire monument also including Neptune and the SD – SMAD SI system of the original statues at the Museum of Messina.



Figure 60. The Roman ship of the Ercolano Museum, recently isolated (in the framework of a collaboration with ENEA) by means of four 3D isolators, each formed by 3 steel spheres rolling between 2 steel plates and a rubber re-centring cylinder for horizontal SI, with a spring and a VD for the vertical one.

## 5 CONCLUSIONS

Two researches [3, 5] showed the importance and effectiveness of a multi-hazard approach, in order to set up GIS databases and building inventories for analyzing historic centers, important for their patrimonial value, prone to natural/anthropic disasters. At the present research stage, the methodology has been enough defined in case of earthquake (hazard mapping, building inventory, architectonic/urban planning, structural vulnerability analyses, strengthening, etc.). On the other hand, further standardization in data storing and application of different vulnerability functions for a larger set of building typologies (including specific algorithms already developed by the scientific community) is necessary. Furthermore, the identification of a global risk factor for a given area (or a building) needs deeper analyses to be carried out in the future.





Figure 61. Recent retrofits with SI in the Russian Federation: the Irkutsk City Central Bank, with HDRBs (left); the National Drama Theatre at Gorno-Altai, with HDRBs and VEDs (at the centre); the Mihailo-Arkhangelskaya Church at Irkutsk City, with HDRBs (right).

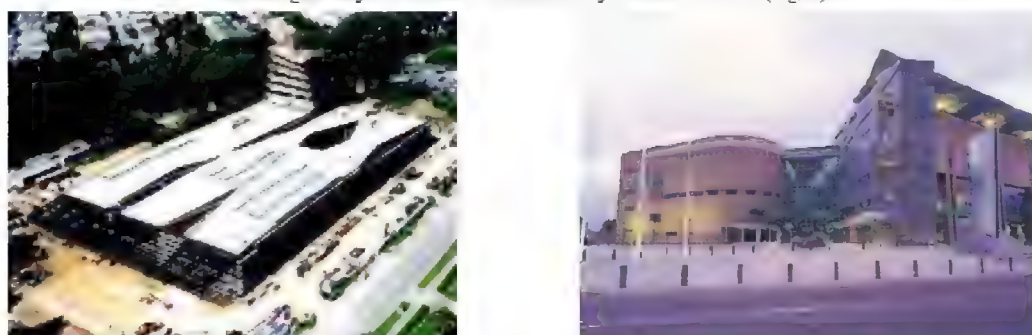


Figure 62. Left: the new seismically isolated Art Museum, rebuilt in the San Francisco Golden Gate Park (USA) in 2005, in place of the previous museum, which had been judged as not sufficiently safe. Right: the seismically isolated "Te Papa" Museum at Wellington (New Zealand).



Figure 63. Left: sketch of the completed Onassis Centre at Athens (Greece). Right: the Acropolis Museum, located in this Centre, during its construction on 94 SIP isolators in 2006.

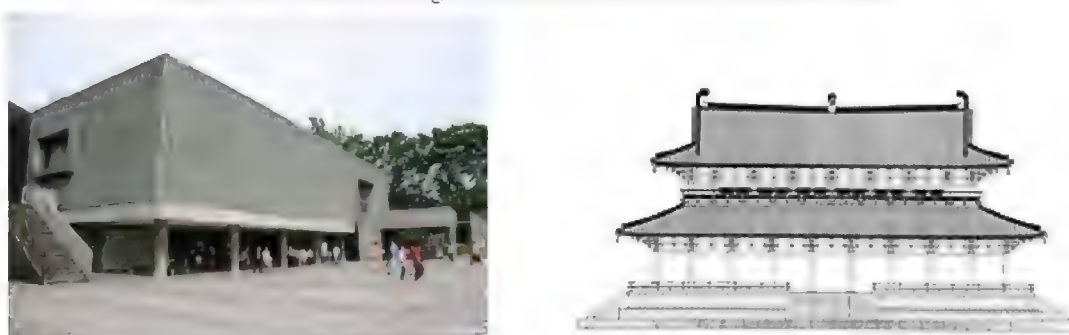


Figure 64. Left: retrofit with sub-foundation and SI of the National Western Art (Le Corbusier) Museum at Tokyo (1999). Right: the "Daigokuden" at Nara, an example of recent retrofits of cultural heritage with SI in Japan, begun in 2001.

The potential of the anti-seismic systems for the protection of cultural heritage buildings and of single art objects, too, is now internationally recognized. Obviously, the latter makes sense only in case that the containing building or surrounding structures (if any) are also adequately protected from earthquakes, so that the fall of debris on the masterpiece can be excluded. With regard to SI, such a potential is so widely recognized that a project for the evaluation of its applicability was jointly proposed by the University of Perugia, ENEA and ALGA even for the marble statue of David of Michelangelo exhibited at the "Galleria dell'Accademia" in Florence (Fig. 70), which, due to its severely fissured ankles, is very vulnerable to seismic and ambient vibrations and might collapse even for

earthquake intensities considerably lower than those expected and already occurred in the Florence area, as stressed for some years [14-15, 27, 33].

For the retrofit of ancient buildings the problem (at least in countries like Italy) remains the need for fulfilling severe conservation requirements, which make the use of SMADs and STUs much easier than that of ED and, especially, SI systems. In particular, the latter may be used, in the aforesaid countries, only after sub-founding the building, which may be a rather complicated and costly task for ancient constructions (e.g. due to underground crypts, etc.). Since, frequently, the conservation requirements can be hardly made compatible with safety requirements, at least in areas affected by a significant seismic hazard, several ancient buildings should not be used any more, in the authors opinion, neither as strategic and public buildings (hospitals, schools, etc.) nor as museums containing masterpieces: new seismically isolated constructions should be erected to host the activities of the aforesaid buildings. In particular, for ensuring an adequate seismic protection of the art objects, SI should be widely used for the construction of new museums and ceilings of archaeological excavations. It is obvious that the SI devices shall be adequately selected, qualified, manufactured, installed, protected and subjected to the necessary inspections and maintenance: otherwise, in countries like Italy, where the seismic code allows for some reduction of the seismic forces acting on the superstructure and foundations (as caused by the SI system), the isolated buildings or objects would be less safe than the corresponding ones with conventional foundations [26-27].



Figure 65. The Iran Bastan Museum at Tehran (Iran), for which retrofit by means of SI has been designed in the framework of collaborations between Iran and Italy.



Figure 66. The reticular ceiling of the Akrotiri excavations in the Greek Santorini island, protected by 92 LRBs and 2 SDs manufactured in Italy in 2003.



Figure 67. The small Chapel of St. Cathoghikheh at Yerevan (Armenia) and sketch of the project consisting in cutting its foundations, inserting a reinforced concrete support slab, displacing the chapel on wheels applied to the slab as shown on the right (so as to make it visible) and, finally, positioning such a slab on NBs manufactured in Armenia.

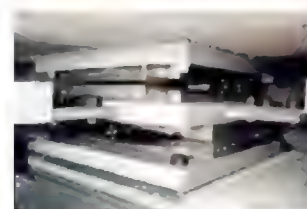
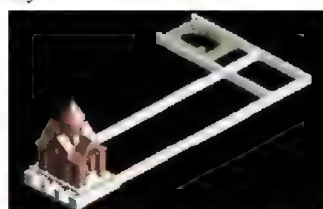


Figure 68. Retrofit with SI of "The Gates of Hell" at Tokyo (1999) and detail of the SI system.



Figure 69. Seismically isolated statue in the People's Republic of China.

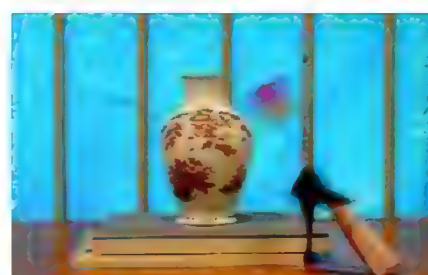


Figure 70. Left: a Japanese "sliding table", with "sphere recirculation" isolators (Fig. 33), used to protect vulnerable electronic equipment and precious art objects. Right: David of Michelangelo, for which a SI project has been proposed.

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# RELICTS OF HIGH THRACIAN CIVILIZATION WITH INFLUENCE OF GEOLOGICAL AND MAN-MADE DISASTERS IN BULGARIA

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## Abstract.

The presence of high Thracian civilization over the territory of the country represents one of the very important factors for the development of the Bulgarian culture. Bulgarian experts make studies various respectable manifestations of the Thracian cultural development with a great interest. The protection of the Thracian heritage was in the past and it is now a difficult task. In a number of cases the Thracian settlements and monuments save considerable traces of geological and man-made intervention, including destruction.

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**Key words:** *Thracians, Sveshtari Necropolis, Starosel Cult Center, Perperikon Sacred Town.*

## 1. Introduction

The ancient Bulgarians began their installation in the Balkan Peninsula in the earliest centuries AD. They brought with them a culture which was based mainly on the achievements of populations in the Asia and NE Europe. After their installation in the Eastern and Central parts of the Balkan Peninsula the ancient Bulgarians met new locally developed cultures. These cultures were represented generally by the installed shortly before them Slavs and by the long-time living in the peninsula Thracians. The Thracians were the main inhabitants over the lands of the new Bulgarian state. Their influence in the Peninsula was very important factor for the regional evolution. The Thracian presence was especially noted in the literature of the ancient Hellas during the 8<sup>th</sup>–6<sup>th</sup> centuries BC.

The permanent contacts of the Bulgarians with the Thracians were of big significance. They permitted the next enrichment of the Bulgarian knowledge and culture. The installation in the Balkans marked a new epoch in the successful evolution of the young Bulgarian state. This intensive state evolution was based on cumulative achievements of integrated Bulgarian, Thracian and Slav cultures and organization, also on Byzantine influence.

## 2. Short historical notes

The Thracian population included numerous tribes. They followed a settled kind of life. The Thracians inhabited well developed settlements. In the settlements they created various products for everyday life of the population, also specially decorated objects for the needs of the most important and rich persons. These belongings took place in a lot of the Thracian temples, tombs and settlements.

In 4<sup>th</sup> century BC Philip the Second of Macedonia and his son Alexander subjected temporarily the majority of the Thracian tribes. Soon the Thracians won back their freedom.

Some later, during the 1<sup>st</sup> century AD the Thracian territory became a Roman province. It was a period of special cares to ensure good transport relations and respectable building constructions. High ways and fortresses noted the Roman strategic ambitions.

In the 5<sup>th</sup> century AD important number of Slavs and some later of the Bulgarians settled in the Balkan Peninsula among the Thracian population. During the late 5<sup>th</sup> century, also in the 6<sup>th</sup>–7<sup>th</sup> centuries, the Slavs and the Bulgarians formed isolated settlements in Central and Eastern parts of the Peninsula. In 681 AD Khan Asparuh founded the First Bulgarian Kingdom on the basis of the Bulgarian, Slav and Thracian inhabitants in the NE part of the Peninsula. In a short period of time the Kingdom was recognized by the Byzantine Empire.

At the beginning the new Kingdom prolonged the politic, economical and cultural traditions of the previous tribes. The contacts among different tribes were formal and administrative. Step by step the relations of the tribes became more direct and fruitful. The representatives of different tribes were included in the state management of the Bulgarian Kingdom.

In this way the Bulgarians with their preliminary Asia-European culture accepted important elements from the Slav and Thracian experience and knowledge. They developed also under Byzantine influence and concurrence. A very new Bulgarian civilization was created in our lands. This civilization inherited the best traditions from the Asia, the NE and SE Europe.

## 3. Examples of Thracian relicts with damages of geological and man-made origin

The Thracian heritage includes numerous tombs, monuments and settlements. Considerable part of them represents very respectable constructions with attractive application of arts. In a lot of cases the investigators find in them significant information on the Thracian historic development and style of life.



Various Thracian tombs, monuments and settlements represent objects of intensive research during the last tens of years. Experts with different specializations participate in the research. Very often there are only relicts from Thracian tombs, monuments, settlements.

Sometimes traces of geological and man-made destructions are noted in the monuments. The manifestations of geological deformation and destruction are related mainly to tectonic phenomena. It is important to underline that in the territory of our state the tectonic movements, mainly the earthquakes, happen relatively often. In these conditions a considerable part of the state represents territory where destructive seismic events were realized and they could take place in the future. Hence, a great part of the Thracian heritage brings traces of natural damages. Moreover, the state was at well visited crossroads situated among Asia, Africa and Europe. The man-made damages were not rare events. They proceeded generally from wars or business concurrence.

Three of the most significant Thracian monuments are included in this study. They are the following ones:

- the Thracian Necropolis at Sveshtary (4<sup>th</sup>-3<sup>rd</sup> century BC),
- the Thracian Cult Center near the village of Starosel (4<sup>th</sup> century BC),
- the Sacred Town Perperikon (5<sup>th</sup> century BC – 7<sup>th</sup> century AD).

3.1. The Thracian Necropolis at Sveshtary (4<sup>th</sup>-3<sup>rd</sup> century BC) is placed in NE Bulgaria, at a distance of about 5 km to NNW from the town of Iserih. The tumulus of the Sveshtary Necropolis (Fig. 1) is only a part of the wide complex of tumuli. It is the Sboryanovo Thracian Tumular Necropolis.



**Figure 1.** The façade of the Sveshtari Tomb (4<sup>th</sup>-3<sup>rd</sup> century BC).

The remarkable Necropolis is situated in the Eastern part of the Moesian Platform. The Quaternary loess is widely extended on the earth surface. It has variable depths, but very often it is deep about 10 m. The limestone rocks of the Lower Cretaceous lay beneath the loess. The local relief is relatively plain with a presence of a number of low hills. The hills are of natural or artificial origin. A number of hills of artificial origin take place in the Sboryanovo Necropolis. One of them is the Sveshtary Thracian Tomb.

The Sveshtari Tomb represents the last home of the buried Ruler. It was built up by the rocks of the local Lower Cretaceous limestone. The Tomb represents an impressive stone-masonry construction covered by terrestrial embankment. Its basement penetrates in the loess. The local geological and geophysical investigations showed that the local basement is not very favorable for the Tomb stability. It is important to underline that in NE Bulgaria there are not considerably different geological conditions for monument constructions.

The Sveshtari Tomb monument is very representative one. Its inner decoration is attractive and imposing. It includes very beautiful sculptures of well dressed nice girls. The individualization of each girl face is remarkable characteristics of the monument (Fig. 2). There is also painting information for the Thracian life and traditions (Fig. 3). A lot of people expressed their deep respect to the Ruler. The Tomb construction saves traces of heavy displacements and fracturing of limestone blocks, partial collapses of vaults and decorative figures (Figs. 2, 3).



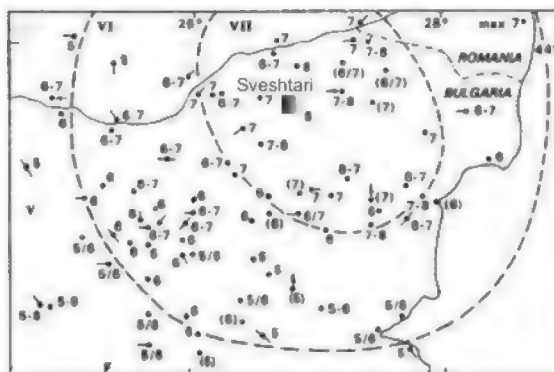
**Figure 2.** A part of the girl decoration in Sveshtari Tomb (4<sup>th</sup>-3<sup>rd</sup> century BC).



**Figure 3.** Picture with expression of great respect to the local Thracian leader (Sveshtari Tomb).



The investigation of the monument destructions shows the presence of most probable influence of moderate and strong earthquakes. The fallen rock blocks (Fig. 2) and the partial deformation of the Tomb walls (Fig. 2, 3) could be in result of occurrence of one or a number of seismic events. The earthquake(-s) could be of local or regional origin, with different depths and respectively with local or regional seismic influence. Seismic events with shallow hypocenters occur in the NE Bulgaria. Other phenomena with intermediate depth happen in the Vrancea region (Romania). The most dangerous for the Sveshtari Tomb seismic event was preliminary dated in the 4<sup>th</sup>-1<sup>st</sup> centuries BC and in the 3<sup>rd</sup>-1<sup>st</sup> centuries BC [1, 2]. Our opinion is that in the Sveshtari Tomb there is a mixed influence of shallow (Fig.4) and intermediately deep earthquakes during very long-time periods.



**Figure 4.** Isoseist map of local 1892 Ispirih (Dulovo) earthquake which effects in Sveshtari Tomb were of intensity 7-8 (the Tomb position is noted by a black check).

The local effects of the erosion have very limited influence over the monument. The Sveshtari Tomb was very long time well-saved by its soil embankment.

The man-made activities of the treasure-hunters create permanent danger for the protection of the monument. The treasure-hunters contributed in the past and they contribute now to several absences in the initial Tomb construction and its contents, also to a part of deformations in the monument.

3.2. The Thracian Cult Center near village of Starosel (5<sup>th</sup>-4<sup>th</sup> century BC) is situated in the Sredna Gora Mountain of the Central Bulgaria. It takes place at about 12 km to the West from the recent town-spa resort Hissar. The cult center Starosel includes a number of tumuli. Six under-tumular temples with very rich king's graves were excavated till now. One of them was situated on the top of Chetinyova hill. The monument has been relatively well protected up to our days. It is a subject of our study.

The construction basement represented a stable territory of granite rocks. The Temple was coated by a thick stone jacket of river pebbles and rough stones. The basement, also the stone jacket, that reinforced the walls, made the construction more resistant to the influence of geological processes, including seismic events. The jacket was of significance for the absence of rockfall phenomena along the tumulus slopes. The jacket ensured good drain of the monument and its surrounding as well. The absence of humidity was of importance for the stability of the construction and for the protection of its inner decoration. The Temple was also covered by a soil embankment. In this way the construction was well protected from the erosion and denudation.

The construction was made by voluminous and heavy granite blocks. Its position, sizes and architecture inspires respect into visitors. In the front of the Temple there are also several well polish blocks of green volcanic rocks (Fig. 5). They give color variety in the monument. The monument included a decorated Entry and an impressive Temple [3]. The Entry and the Temple possessed a relief and multicolor decoration (Fig. 6). The decoration testified the artistic and the technical skills of the Thracians (Figs. 5, 6).



**Figure 5.** The frontage of the Starosel Temple



**Figure 6.** Decoration of the Entry

situated on the top of Chetinyova hill (4<sup>th</sup> century BC).

in the Temple on the Chetinyova hill.

The earthquake influence from the side of the seismically dangerous neighbor Maritsa fault zone over the Starosel Cult Center was very limited. In this case the construction was well elaborated and placed over stable granite massive in locality without shallow groundwater.

This monument, like a lot of other Thracian ones, was partially damaged by old and contemporary treasure-hunters. It is one of several monuments with similar problems in the region. It is difficult to estimate whether the damages caused by the ancient treasure-hunters were bigger or those ones recently made by their colleagues. Now the problems related to the protection of the monument are not stopped.

3.3. The Sacred Town of Perperikon (5<sup>th</sup> century BC – 7<sup>th</sup> century AD) is another very important Thracian complex (Fig. 7). The complex is formed in SE Bulgaria, in the Eastern Rhodope Mountains, at 15 km to NE from the town of Kardzhali [4].



**Figure 7.** Position of the Sacred Town of Perperikon (5<sup>th</sup> century BC – 7<sup>th</sup> century AD) on hill of Eastern Rhodopes.



**Figure 8.** Fragment with the high rocky altar from the supposed sanctuary of the God Dionysus-Zagreus situated in fractured rocks.

The monument took place on isolated rocky hill of the Eastern Rhodopes Mountains. It was situated in the wide NE Rhodopean Depression where the Paleogene sandy limestone and Paleogene volcanic rocks were very well distributed. The monument was cut in the local sandy limestone.

The Sacred Town had good strategic position. It was founded near a very fertile valley and very close to the Perperik River. Long ago, during 5<sup>th</sup>-4<sup>th</sup> millennia BC, the hill was deeply respected by the local people. In times before the Thracians' coming, the population made its sacrifices on the hill. The Thracians saved the local traditions. They prolonged the visits of the hill and they enlarged the sizes of the sacred territory. During 5<sup>th</sup> century BC the Thracians transformed the locality into a respectable sacred center. The Thracians prolonged the local traditions of the population. A number of premises were cut additionally in the rock massive. Scientists suppose that the sanctuary of the ancient Thracian God Dionysus-Zagreus in the open air (Fig. 8) was one of the most important among the new constructions.

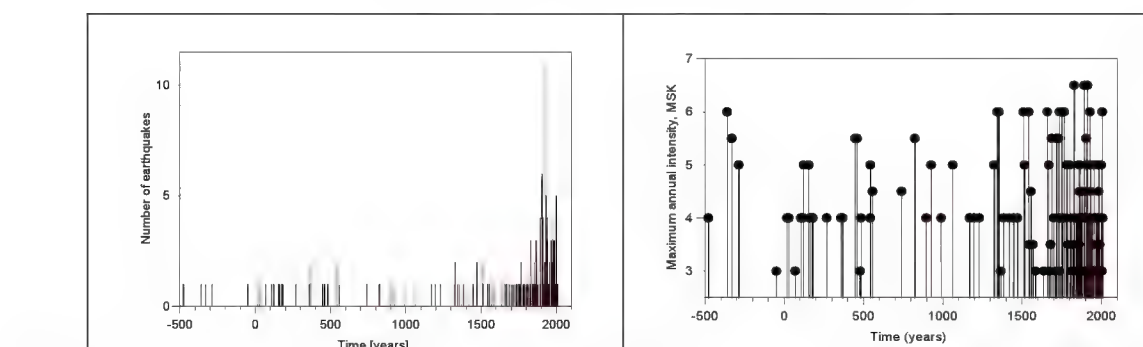
Later, generally after the 7<sup>th</sup> century AD, the monument was partially destroyed as a result of social needs and natural factors. The widely distributed orthodox churches were more visited than the ancient sanctuary. For very long time the sacred town was without any protection during its long history. The invasions of foreigners contributed to additional destructive manifestations. The ancient and contemporary treasure-hunters took participation also in the monument damages. Shortly, the man-made danger is considerable.

Various geological processes, mainly local and regional earthquakes, other tectonic movements, intensive erosion, rockfalls and karstification, caused the deformation in the monument. The geological events occurred there during the thousands of year existence of the respected hill.

The archaeologists propose not very correct data for the seismic activity of the locality. They suppose generally the occurrence of strong earthquakes that contribute to the damages in the hill and the sacred town. The investigations have been not stopped.

The seismological information is relatively limited in time, but it includes more sure data for the occurrence of weak and moderate seismic events with influence to the locality. The seismic loading of the study region (Fig. 9, data from publications [5-16]) might be considered as refers to dangerous attacks from the seismic activity of the North Anatolian Fault. Unfortunately, the seismic information is with gaps concerning the rest part of the potential origins of threat. The obtained data are not complete due to many centuries administrative dependence of Bulgarian lands from foreigners during the Byzantine slavery (11<sup>th</sup>-12<sup>th</sup> centuries) and the Ottoman one (14<sup>th</sup>-19<sup>th</sup> centuries).





**Figure 9.** Seismic impacts on the Perperikon area during 25 centuries: amount (left) and strength (right).

The strongest seismic impacts came from Lower Thracian Depression (1829) and the area along North Anatolian Fault in NE and Northern sectors of the Aegean Sea (1766, 1893). The periods of seismic activity in the very dynamically developing neighboring region of Marmara and Aegean Sea (360 BC, 1344, 1353, 1542, 1659, 1737, and 1912 AD) and in the nearby situated zones of the Upper Thracian Depression (1928) are of great significance for the instability of the monument as well. The earthquakes in the nearest territories of the eastern part of the Thracian Depression (1509, 1752) also contribute to the seismic effects in the locality. The maximal seismic influence might be assessed up to intensity of 6-7 degrees according MSK-64. The intensity is not very high, but the occurrence of numerous earthquakes during long-time period represents a serious factor for damages in the Eastern Rhodopean massif, including in the studied Perperikon site (Table I).

**Table I.** Seismic impact on Perperikon area.

Epicentral Region	Maximum impact on Perperikon by intensity MSK	* Source of information
Marmara Region	6	[ 5 – 9 ]
Aegean Sea	6-7	[ 10 – 12 ]
Vrancea region	5	[ 13 – 14 ]
Low Thracia	6-7	[ 6, 12 ]
Upper Thracia	6	[ 15 ]
Local & imminent vicinity	6	[ 15 ]

\* The source [16] is in use for all regions.

The influence of the various tectonic processes is considerable. Now the hill and the monument have fractured (Fig. 8). There are displaced blocks of great sizes.

The manifestations of erosion and weathering play also significant role for the recent deformation of the rocky hill with the studied monument. The Sacred Town represents totally an open air construction. The changes in the temperatures and humidity, also the wind activity provoke direct influence over the monument. The cited geological phenomena cause the disintegration of the rocks and of their mineral components. The rocks lose their solidity. The sandy limestone of the Sacred Town is also subject of karst processes. The karst development is related to considerable disturbance in the compactness of the limestone massif. Tectonic movements, including earthquakes, also the erosion, the weathering and the karst phenomena represent dangers for the protection of the Thracian monument of Perperikon. They contribute to deformation of the Sacred Town of Perperikon. The stability of the monument is decreasing.

#### 4. Conclusions

Thracian tumuli are widely distributed in the territory of Bulgaria. A part of them indicates the directions of high ways and roads, other ones represent Tombs or Temples. During the long time of their existence a number of tumuli was destroyed totally or partially as a result of the human and geological activity.

The discovery, opening and research of the numerous Thracian tumuli is increasing in the latest tens of years. This work is very important for the study of the Bulgarian, Mediterranean and European history and for the development of the civilization.

The Thracian monuments represent very important contribution to the national and world cultural heritage. Their importance is well assessed by national and world cultural organizations like UNESCO. The Sveshtari Necropolis represents a monument of world significance included in the List of UNESCO for world cultural heritage. The Starosel Cult Center and the Sacred Town of Perperikon are among the new scientific discoveries. Now they are of national importance, but they will be proposed also for the List of UNESCO.

The Thracian tumuli with monuments propose very important information for the life and the culture of ancient inhabitants of our lands. They give also data for various human activities and for their equipment, for the level of the scientific and technical development of the ancient societies. They are attractive for scientific and engineering investigations.

The monuments throw light on the historic development of localities, regions and states. They save traces of positive or negative impacts on them from the side of the people, society and temporary created situations.

The Thracian monuments are very interesting from geological point of view as well. From them we could obtain significant data for the occurred earthquakes and other geological manifestations. We receive knowledge about effects from long-lasting geological processes.

The ancient Thracian monuments represent also attractive sites for the visits of national and foreigner tourists. The tourists receive esthetic pleasure and they acquire historic erudition during their visits in the Thracian monument sites. They assess highly the significance of the SE Europe for the evolution of the continent and of the world.

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# CULTURAL HERITAGE OF MAIN BULGARIAN CITIES WITH EARTHQUAKE TRACES

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## Abstract

The monuments of the main Bulgarian cities, Sofia and Plovdiv, also of the educational center Svishtov, have survived many moderate and strong seismic impacts. The monuments in and around these localities are related to different periods of historical development; the earliest relics refer to the 5<sup>th</sup> millennium BC. This study is devoted to the importance of the cultural heritage in nowadays Sofia, Plovdiv, Svishtov and the earthquake traces been kept for centuries.

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**Keywords:** Bulgaria, cultural heritage of main cities, earthquake impacts, seismic danger

## 1. Introduction

Numerous cultural monuments of different origin are spread over the territory of Bulgaria. In many cases they include only European elements, in others – a combination of elements from more than one continent, mainly from Asia and Europe. Considerable part of the monuments bears destructions caused by natural or man-made phenomena. The present investigation deals with some cultural monuments in the cities of Sofia, Plovdiv and Svishtov where earthquakes cause demolishing effects and the seismic danger provokes special care over protection of the cultural heritage.

## 2. Historical notes

Every person is proud of the cultural history of his country. We are not any exception. Our ancestors came from Asia after a very successful development there. On the way of their migration, they established a Bulgarian State along the Volga River in the first centuries AD. Later on, some part of proto-Bulgarians continued to the Balkan Peninsula and formed a new Bulgarian State in the 7<sup>th</sup> century AD. They took place for permanent installation in the neighborhood of the powerful Byzantine Empire, a decision that needs special respect. Today, our state is the only one in Europe without any changes or transformations in the name during its long history.

The ancient Bulgarians brought a significant Asian culture and certain traditions in a good organization of the population. They successfully mixed their culture with the regional one in the Balkan Peninsula. The latter fitted together achievements of the very high civilized Thracians, very close to the nature Slaves, and the highly educated neighboring Byzantines. On their part, the Bulgarians distributed their social and state organization among the Thracians and the Slaves.

The Bulgarian lands are in the south-eastern Europe, visited by various foreign populations, mainly from Asia and Europe, with good or bad intentions. They have left supplementary traces into the home culture but they pulled down settlements as well.

The cities Sofia, Plovdiv and Svishtov are of importance for both, the ancient and recent development of the state. They have a history of several thousands of years. Their culture includes traditions of different populations and generations. The monuments they left in Bulgaria have protected the mixture of multinational spirits during the long historic evolution. These monuments have been well or bad safeguarded till the present days.

Sofia is the state capital. The inhabitants are about 2 000 000 at present. The City is one of the oldest in Europe. It was established in a plain between two mountains, Vitosha and the Balkan, over 5 000 or 7 000 years ago according to different historical data. It has been attractive for centuries with its position at crossroads, in a fertile plain at the foot of Vitosha Mountain, and numerous mineral water sources. In the 3<sup>rd</sup> century AD it became the capital of the Roman province Dacia. In the 6<sup>th</sup> century Emperor Justinian created solid fortification walls for the city safeguard. At the beginning of the 9<sup>th</sup> century the city was included in the Bulgarian Kingdom. It grew a political, economical, cultural and military center. In the 11<sup>th</sup> century the city fell under Byzantine domination. Crusaders recaptured it in the 12<sup>th</sup> century. Since 1194 the city was again included into the frames of the Second Bulgarian Kingdom; so it got into circumstances to be well developed. In the 14<sup>th</sup> it fell under Turkish domination and was liberated even in the 19<sup>th</sup> century second half. After The Liberation the city was proclaimed capital of the state which was the start of its very intensive administrative, political, economic and cultural evolution. The cultural monuments are generally of Bulgarian, Russian, Turkish, Austrian and Jewish origin.

Plovdiv is the second largest city in Bulgaria; its inhabitants are more than 350 000. It is also ancient city with very rich history [1]. Its position on crossroads between the Western and Oriental Europe is favorable for its evolution. The city was built up over 6 hills along the Maritsa River. The city inherited a pre-historic settlement from the second millennium BC. In the 3<sup>rd</sup> century Philip II of Macedonia conquer but the local population of Thracians succeeded to liberate the settlement. In the earliest centuries AD the Romans installed their administration in the city and the Peninsula. They built up a very hard fortress and included in it 3 of the city hills. Theatre, baths, administrative and residential buildings were erected within the fortress. After the Romans, Slaves managed the life of the city. In the 11<sup>th</sup> century the city was included in the territory of the First Bulgarian Kingdom. In 14<sup>th</sup> century

the Turks captured the city and it grew into an administrative and military centre. During the Bulgarian Revival period the city was playing an important role for the promotion of the state and its culture abroad. After The Liberation the city became the capital of a part of Bulgaria, the Principality Eastern Romelia (1878-1885). Now the city is a significant economic, cultural and educational center of Southern Bulgaria. Its cultural heritage is very significant.

Svishtov is exceptionally important by its very good educational traditions. Its inhabitants are more than 30 000. The town was built in tiers over the terraces of Danube River. In its surrounding the Roman town Nove was built up; its strategic importance was considerable. Later on it was transformed in a Byzantine town-castle on the northern border of the Empire. Relicts of the ancient Nove were used to erect the Bulgarian mediaeval castle Kale. The town was included in the Bulgarian Kingdom in the 9<sup>th</sup> century. During the mediaeval Revival the town grew bigger. The renovation of its buildings, roads and craft productions was significant. The commercial relations with the Danubian countries and Dubrovnik increased very rapidly. Documents note about annual economic fair in the early 18<sup>th</sup> century. Svishtov was the first Bulgarian town liberated by the Russian-Romanian-Finland-Bulgarian army from the Turkish Domination. The cultural life of the town was intensive. Many local intellectual leaders contributed to the town development. The first Bulgarian Library-cultural club with Museum was founded there in 1856. Economic High School and Commercial Secondary School were established in the town at the end of the 19<sup>th</sup> century. They were attractive for the most progressive professors and the young people.

### 3. Geological position and seismicity of Sofia, Plovdiv and Svishtov

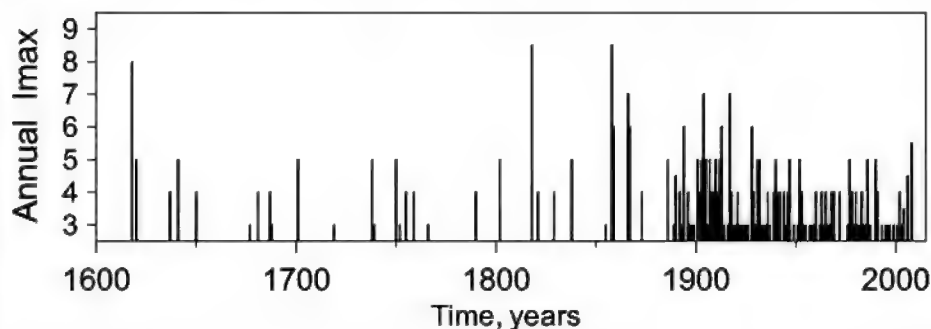
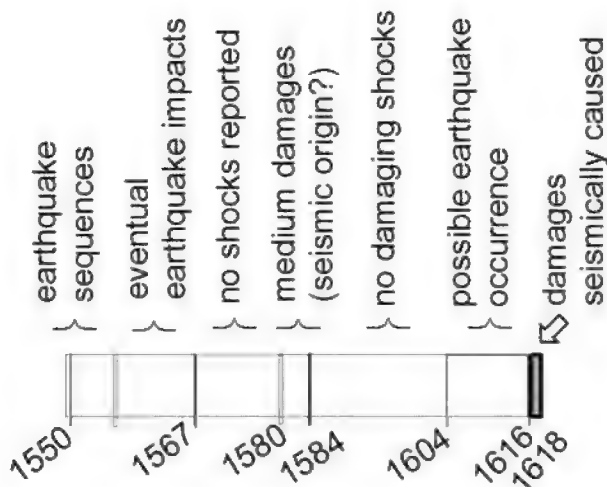
Sofia and Plovdiv cities are situated in the mobile tectonic zone of the Sredna Gora. It is a tectonic unit with Alpine development. The Sredna Gora tectonic zone represents one small fragment of the well-known for its recent mobility Alps-Himalayan tectonic belt.

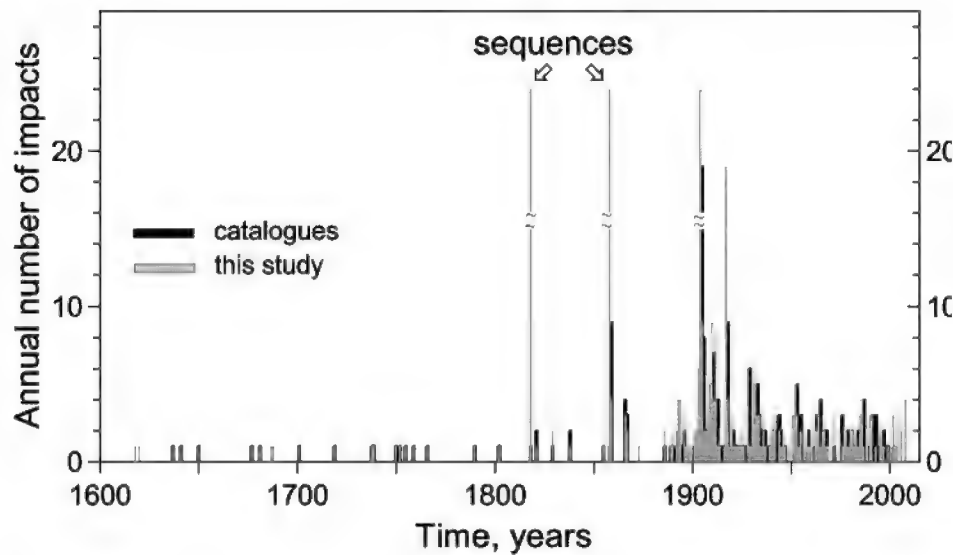
**3.1. The Sofia city** lies in a relatively small Graben with the same name. The Sofia Graben is young one, of Neogene-Quaternary age and its development is fairly considerable. The Graben shows tendencies of subsidence of various intensities and the surrounding horsts - of specific uplift. Numerous faults cut the Graben and create small blocks (Fig. 1) included in horizontal and vertical displacements. The acquaintance with the seismic history of the cities under study refers to a rather short time-span in comparison with the long existing cultural life of Serdica-Sredets-Sofia as well as of Philipopolis-Filibe-Plovdiv and Nove-Svishtov. The only written sources about natural events in the deep past of Bulgarian lands are Hellenistic and Byzantine chronicles. They have been exhaustively studied yet [2]; any hint at seismic events over the places of our interest hasn't been found therein. Since the late 14<sup>th</sup> century on in the time of Ottoman domination, the only centers of education and culture were the religious places. Unfortunately, some of the Christian objects were obliterated, others - abandoned or transferred into Muslim prayer homes. In fact, the historical data on earthquakes are problematic and predominantly uncertain ones. The seismicity of Sofia Graben and adjacent horsts is significant. There are data and registrations of numerous small and limited quantities of moderate to strong earthquakes with magnitude up to M 6.5 (Fig. 1, [3]). Remarkable Sofia earthquakes are known to have occurred in 1818 and 1858. The April 1818 excitation of intensity between 8 and 9 was supervened by another with intensity 7 in September the same year and many weaker quakes between and after. An earthquake series shook Sofia in 1858-1859 (it lasted more than a year), being very rich at the beginning (54 shocks during the first 3 days; 130 events till the 18th day after the mainshock). The earthquakes originated in this case at the southern flank of the Sofia Graben. They were accompanied by coseismic cracks and big changes in mineral water capacity. The intensity in Sofia might have been accepted 8 EMS or a bit higher.

To the purpose of safeguarding the cultural heritage, it is important to go deeper into the past seismicity of Sofia. Logical analysis on contemporary documentation discovers the seismic life of Sofia in the time-span since about 1550 to 1618. More or less certain occurrences of single earthquakes and earthquake sequences were alternated, as it is shown in Fig. 2. The seismic history of the Sofia city can be continuously presented since the early 17<sup>th</sup> century thanks to the materials of the Bulgarian Seismological Service as the Macroseismic Archive of the Geophysical Institute, Sofia, and published macroseismic bulletins, some compilations and studies on individual earthquake series, as well as catalogues and isoseismal maps for Bulgaria and the Balkan Peninsula. Some very new data retrieved in Bulgarian libraries are also added to them.

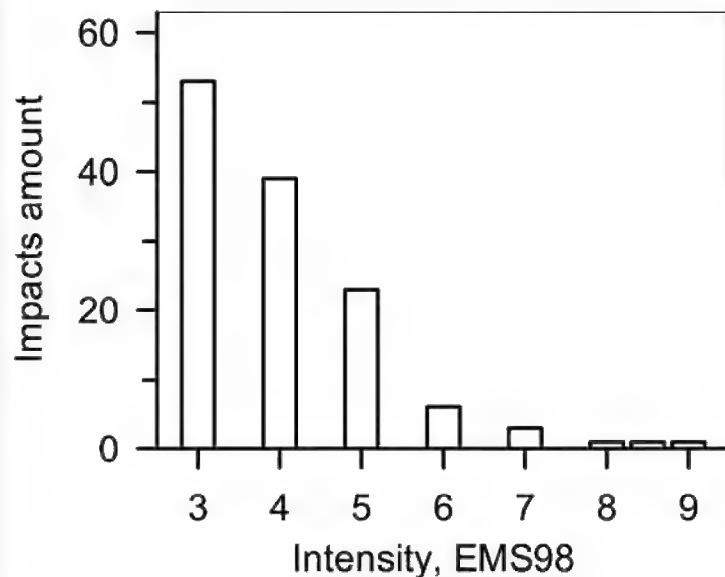
The seismic impacts time distribution since the 17<sup>th</sup> century till the present day is shown by intensity of excitation in Fig. 3a, and by the amount of impacts in Fig. 3b. The impacts amount versus intensity degrees for the last four centuries is shown in Fig. 3c. Totally around 300 impacts to Sofia are identified. Going backwards, the information becomes more and more scarce and uncertain. Evidently, the macroseismic data set at disposition is incomplete.

Impacts to the city come from different seismic regions, some of them being near and others far away. The greatest threat to Sofia comes from local earthquake sources. But the acquaintance even with the local seismicity is not possible to become better for the present; this is well affirmed by the gaps on the distributions plotted in Figs. 3a,b, especially in low intensity ranges.

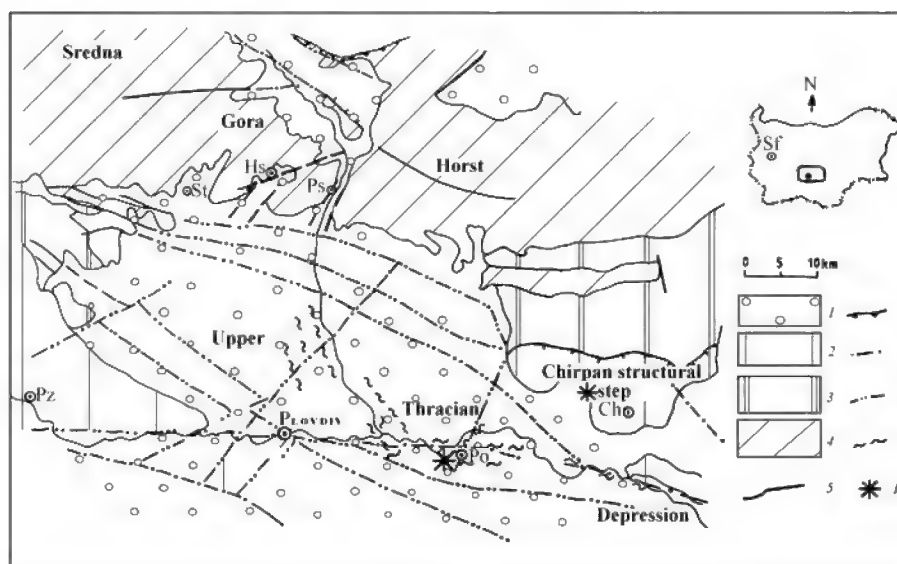




**Figure 3.** Seismic history of Sofia city since the 17<sup>th</sup> century till the present:  
(b) annual impacts amount



**Figure 3.** Seismic history of Sofia city since the 17<sup>th</sup> century till the present:  
(c) impacts amount corresponding to each intensity degree, EMS98



**Figure 4.** Main structures in the Central part of Sredna Gora tectonic zone ([9], complemented by one of the present authors) and epicenters (asterisks) of the strongest 1928 South Bulgarian earthquakes:  
1 – Tertiary-Quaternary sediments, 2 – Upper Cretaceous-Paleogene neointrusives, 3 – Upper Cretaceous deposits, 4 – Caledonic-Hercynian granitoides, 5 – normal fault, 6 – thrust, 7 – covered fault, 8 – unsurely traced fault, 9 – seismically induced fault, 10 – epicenters.



Regardless of all troubles, some not-known events have been added to the already known thanks to processing data from studies, periodicals and compilations [4-8, Bulgarian newspapers (1858 - 1886)]. There are four impacts of a moderate strength in 1687, 1867, 1873, 1886; one 8 degree hit from the local origin most likely in the period 1616-1618; some quantity evaluations to the 1858-1859 local seismogenic process; several eventual impacts from non-local 18<sup>th</sup> century seismic events (the 1719, 1766 Marmara Sea, 1752 Edirne, and the 1759 Thessaloniki earthquake).

Summarizing, two accents can be noticed:

- Referring to the strength of seismic excitations to Sofia, both the earthquake origins in South-Western Bulgaria and the local sources are most dangerous. These origins are capable to provoke a catastrophe in Bulgaria - just to remember experienced impacts: intensity higher than 8 MSK from local seismogenic sources, and intensity around 7 from external regions.

- Concerning to the frequency of seismic impacts to Sofia, a cautious conclusion can be drawn. Intensity between 7 and 8 EMS might be expected no later than in the second half of this century. This proceeds from the intensity recurrence expressed by equation:  $\ln(N/yr) = -0.85 \cdot I + 1.146$ ; this relationship is produced by independent local shocks occurring after establishing of Bulgarian Seismological Service.

**3.2. Plovdiv City** is situated in the Upper Thracian Depression. The depression represents a wide and very complicated graben structure. It covers vast territories of the Sredna Gora zone and it is the most impressive negative structure there. The depression was created during the Tertiary and Quaternary. It proceeds from compensative block subsidence with regards to the uplift of the neighboring structures. Geophysical prospecting testifies the presence of numerous faults and blocks in the basement of the Upper Thracian Depression. Both, horizontal and vertical displacements take place along the faults. The blocks are moved either in vertical and horizontal directions. The amplitude of their cumulative vertical displacements reaches up to 700-1 000 m.

The seismic activity in the Upper Thracian Depression together with its boundary faults is at the second chief position among the seismogenic zones of Bulgaria. A great number of earthquakes are noted in its history. The 1928 South Bulgarian earthquakes (M 6.8, 7.0) are the latest representative among them (Fig. 4).

The epicenters of the 1928 South Bulgarian earthquakes are localized not far from the Plovdiv city. The strongest seismic events and the four-year lasted seismic activity caused destructions in buildings, supporting life lines, difficulties in transport, changes in mineral source flow, also co-seismic emergence of cracks on the earth surface and different seismic-hydrogeological phenomena (Fig. 5).

Due to the great threat of unfavorable geodynamical phenomena, it is worth summarizing some main seismological aspects of the area around Plovdiv. The earliest information on earthquake consequences in the town of Plovdiv (the then Philipopolis-Filibe) came from the October 1750 issue of the newspaper Gentelman's Magazine:

*"An earthquake at Philippoli, one of the best cities in Romania [common name of European territories of the Ottoman Empire], has almost swallowed up the place and destroyed [? homes of] 4000 persons; and most of the towns, and villages, in the neighbourhood have been demolished by the violent and repeated shocks, or laid under water by the overflowing of the river Mariza."*

Evidently, earthquake activation was set in over the Maritsa seismic zone in 1750. The intensity in Plovdiv might have been assessed between 8 and 9 EMS.

One of the valuables of Plovdiv, its Clock Tower, was firstly documented in 1665. At that time the theologian Taferner passing through Plovdiv in an Austrian diplomatic mission to Istanbul, wrote:

"... There is a clock tower in Plovdiv; it is to be noted that it has been here since many years... It is said that even Istanbul and Edirne do not possess any similar clock." [10].

Six decays after the 1750 damage the clock tower of the town was rehabilitated. This is evidenced by a Turkish text on the marble plate: "In 1227 (1812) this clock has been restored." [11].

Next information on earthquakes in Plovdiv was left in [12] by a commercial official who arrived at the town of Plovdiv on his way from Istanbul to Vidin on 18 January 1811 in the afternoon. The introduction to his diary sounds:

"The Maritza river valley has often been subjected to earthquakes. I personally took great "pleasure" in feeling two shocks just in the evening of my arrival."

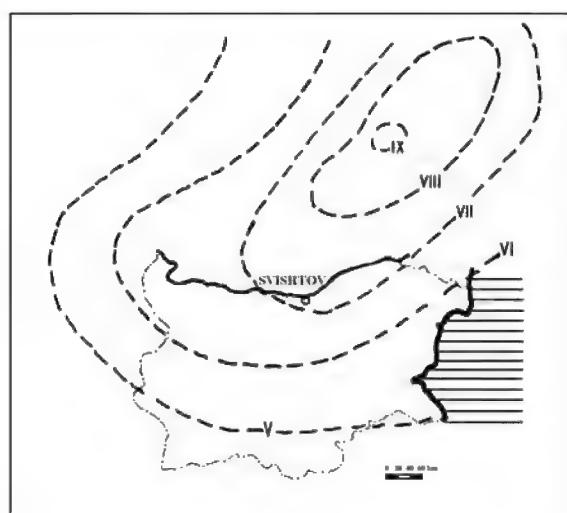
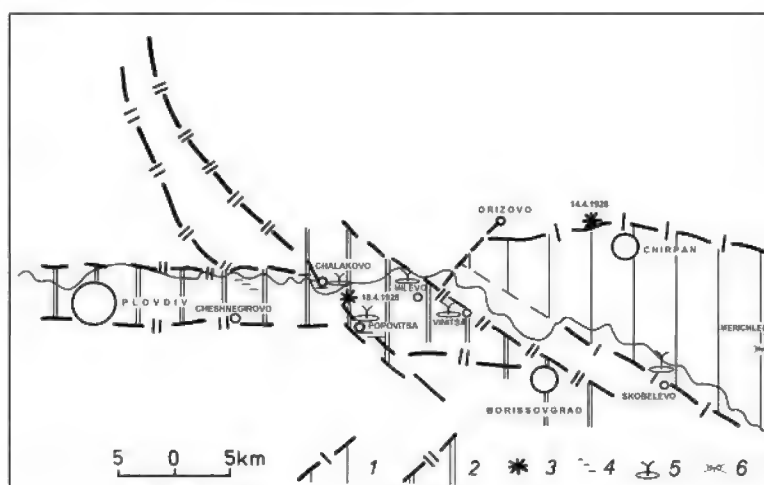
Further on, the reader becomes known about details. The sequence of earthquakes had started "two years ago". In the cited case, the intensity at Plovdiv should be about 6 EMS (great fear but no damages).

These sporadic examples of past earthquakes show how difficult is to retrieve earthquake occurrences in previous centuries. This is only one of the aspects to be decided. Another one is that the earthquake realization in the Plovdiv imminent vicinity is too frequent, irrespectively that the powerful seismic events occur not often. However, the fault sizes in the region show significant potential.

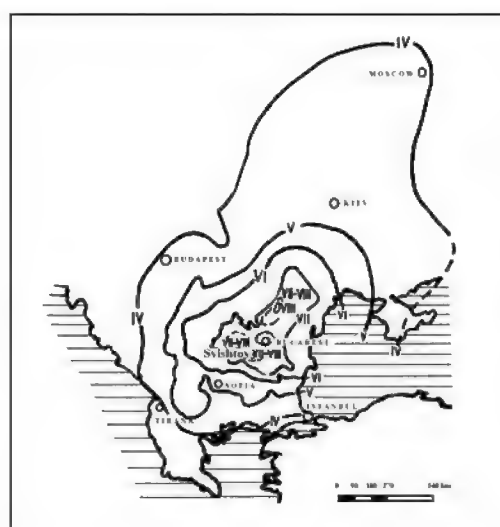
**3.3. The town of Svishtov** takes place in the Moesian Platform. The local tectonic manifestations, including the earthquakes, in the Platform unit are relatively limited. A great seismic threat, however, comes from the intermediately deep Vrancea source (Romania). (Fig. 6, 7).

**Figure 5.** Faulting and appearance of seismic-hydrogeological phenomena as a result of 1928 South Bulgarian earthquakes.

1 – fault-boundary of structures in the Sredna Gora tectonic zone, 2 – fault-boundary of seismically activated block, 3 – epicenters of 1928 Southern Bulgarian earthquakes, 4 – subsided territory, 5 – space with manifestation of water fountain, 6 – temporary stop of mineral source.



**Figure 6.** Effects of 1940 Vrancea earthquake ( $M_w 7.7$ ) [13]: intensity of 7 MSK in the town of Svishtov



**Figure 7.** Effects of 1977 Vrancea earthquake ( $M_w 7.5$ ) [13]: intensity of 6 to 8 MSK Svishtov in the town of Svishtov



**Figure 8.** St. Sophia church: at present (on the left) and after the 1858 earthquake (on the right) [14].

The basement of Svishtov town includes mainly carstified limestone at the Lower Cretaceous age. The relief of the high Danube River bank and the presence of eroded limestone create conditions for the development of landslide, rockfall and land subsidence phenomena. Such a complicated situation has stimulated appearance of a variegated macroseismic picture and considerable damages.

#### 4. Seismic affects to cultural monuments in studied cities

**4.1. Sofia City.** A great number of seismic impacts to Sofia during 16<sup>th</sup> and the early 17<sup>th</sup> century caused damages in churches of Sofia City and its surrounding. The church “St. Sophia” (4<sup>th</sup> century AD) in the city present centre (Fig. 1, 8), the church “St. Georgi” (15<sup>th</sup> century AD) of the Kremikovtsi monastery in the northern city periphery (Fig. 1, 9) and the Boyana church (11<sup>th</sup> - century AD) in the southern city periphery (Fig. 1, 10) are among them. During the 1858 Sofia earthquake (M about 6.5) representative monuments of the city obtained latest deformations. The deformations were provoked due to topographic reasons, shallow ground waters and ensuing phenomena like land subsidence and landslides. The deformations in the constructions were followed by considerable periods of repairing that took place in the same or in the next centuries.

The seismic history of St. Sofia church (Fig. 8) is very interesting [14]. The church gave the name of the city in the Middle Age because it was its most remarkable construction. At the beginning it was a small chapel-martyria. Later it represented very remarkable church. Only during the 5-centuries of the Ottoman Domination the church was temporary transformed in mosque. The 1858 earthquake destroyed a part of the mosque including its minaret (Fig. 8, on the right). Even after The Liberation the mosque was again transformed into church and later on totally reconstructed.

The Kremikovtsi church “St. Georgi” (15<sup>th</sup> century) is one of the numerous churches and monasteries in the surroundings of Sofia city. The church was founded by a rich Bulgarian family with help of the Sofia Orthodox representatives. Its inner decoration was very attractive. It included numerous traditional Orthodox subjects, also several very original pictures - illustrations of the life in Bulgarian village (Fig. 9, right). The church construction saved traces from the 16-17<sup>th</sup> century seismic impacts to Sofia; they provoked a local subsidence and landslide in its southern wall.

The Boyana church (11<sup>th</sup> century AD) has special importance for the world and national history of the art. At present, the church is included in the List of UNESCO for the world's cultural heritage. The monument was a small construction built of bricks. The painter of the church in the 13<sup>th</sup> century was a famous one. He was deeply impressed by the beauty of Dessislava, the wife of the local lord, as well as by the intelligence of her husband Kaloyan. Inspired, he executed very good portraits of the lord's family and especially of Dessislava (Fig. 10, right). Under the influence of numerous 16<sup>th</sup>-17<sup>th</sup> century earthquakes the church was partially damaged. In 1633 it was reconstructed [15]. On account of the 1858 earthquakes the church again received some deformations. The seismic effects are related to the location of the church which is very close to a seismically activated sector of the large Vitosha fault (Fig. 1). Several co-seismic rockfalls took place near the church.

**4.2. Plovdiv City.** The South Bulgarian earthquakes in April 1928 (M 6.8 and 7.0) which caused activation of the Maritsa fault system for four years forth, made considerable destructions in the city [16]. The impressive consequences were well studied by Bulgarian and Serbian scientists. The affected territory covered by young incompact soils and rocks, in that spring season was with very shallow ground waters. These circumstances contributed to manifestation of numerous destructions. The old quarters near the Maritsa River were significantly destroyed. A lot of Orthodox (Fig. 11, on the right) and Catholic churches, also Turkish mosques received considerable destructions.

Many architectural monuments of Plovdiv City, like the Military Club of the city, the International Catholic hospital, hotels, etc, received hard damages or were demolished. For instance, the earthquake caused total destruction of the Plovdiv Military Club (Fig. 11, on the left). Prior to the shocks it was a very attractive construction. It included library and theatre so that was significant for the city's cultural life.

The reconstruction of buildings and monuments, bridges, high ways and rail ways after the 1928 earthquakes was perfectly organized. Financial support for restoration came from the Bulgarian government and along the line of the Red Cross from many foreign countries. Lot of heavy damages taken place in Plovdiv City and wide territories of the surrounding region were eliminated in a short period.

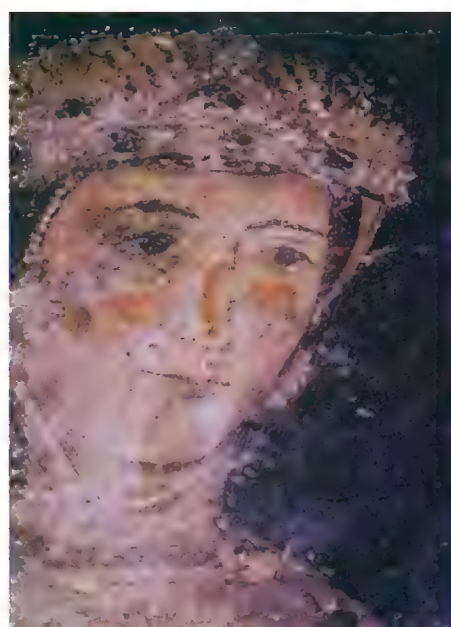
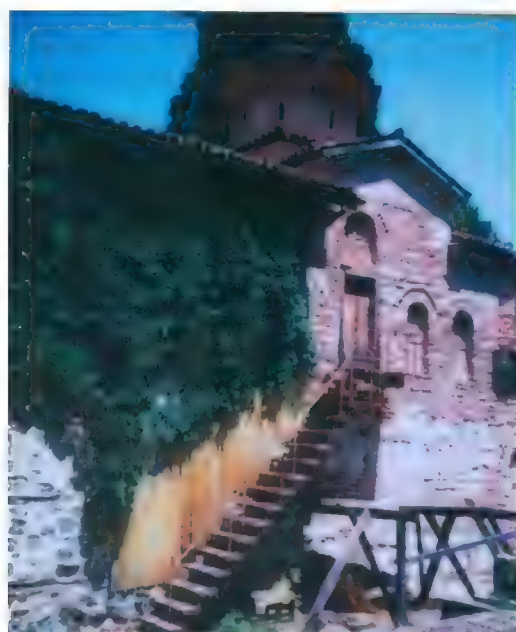
**4.3. Town of Svishtov.** The 1940 and 1977 Vrancea (Romania) intermediate deep earthquakes ( $M_W$  7.7 and 7.5) provoked considerable seismic effects along the Danube River and in a great part of North Bulgaria. The 1977 event is known with more than 100 human victims in the town of Svishtov, significant destructions and heavy financial consequences.

Administrative and residential buildings, factories, schools, churches and monuments were affected. The Economic College (old Commercial Secondary School) in Svishtov, established in 1910, was among them (Fig. 12). It is a cultural monument for the development of the education in Bulgaria. The school was a two storey construction with very representative façade and interior. Mosaics and paintings covered its walls. The seismic event destroyed the school. Several other cultural monuments, including a fine church built by the famous Bulgarian master Kolyo Ficheto and decorated by the great Bulgarian painter Nikola Pavlovich, obtained limited deformations. The cited church had 2 rotated columns at its entry. They were made especially for the control of the construction's long-time

balance. After the 1977 earthquake the column rotation stopped. This phenomenon represents a good indication for the presence of deformations in the church construction.



**Figure 9.** Kremikovtsi monastery (on the left); Church “St. Georgi”-original Bulgarian elements in decoration (on the right).



**Figure 10.** Boyana church -exterior (on the left); fragment of the portrait of Dessislava (on the right).





**Figure 11.** Consequences from 1928 South Bulgarian earthquakes (M 6.8, 7.0): the Military Club in Plovdiv (on the left), the St. Spas Church in Plovdiv close vicinity (on the right) [16].

## 5. Main decisions for protection of people and constructions

The first and the most important care for the population, its constructions (homes and offices), including the cultural heritage, is represented by the seismic zoning of the state (Fig. 13). A step afterwards is more detailed seismic zoning (microzonation) of the main cities and the spots of most important constructions.

The next expression of attention to the cultural heritage is directed to elaboration of numerous regional and local projects for investigations devoted to arising of deformations in the cultural monuments. These investigations are based on various geological, geophysical, geochemical and engineering experiences.

Very often in practice, monitoring of deformation development in various monuments is applied. The occasional research on deformation processes could not be a sufficient though. The non-stop control about the evolution of the destructive phenomena is of great significance for the protection of the cultural heritage. Naturally, drastic measures to reduce the structure's vulnerability as well as to make better the sub-fundament soil conditions are of exceptional importance.

## 6. Conclusions

The territory of Bulgaria is rich of cultural monuments built up in numerous historic periods. They are created by different populations. Therefore they express various traditions. In these conditions every later monument has accumulated the culture of his generation and of the previous generations and populations.

The cultural heritage in Bulgaria has mixed character. It is wealthy with the presence of European and Asian elements. We owe this mixture of cultures to the Asia-European origin of our forefathers.

Numerous ancient and recent cultural multinational monuments in Bulgaria have traces of strong and moderate earthquakes. The experts make analyses of the earthquake-induced destructions and they try to protect the old monuments and to create modern ones. The successful protection of the old and new monuments is carried out on the basis of the scientific and practical knowledge that has been accumulated during our long history.

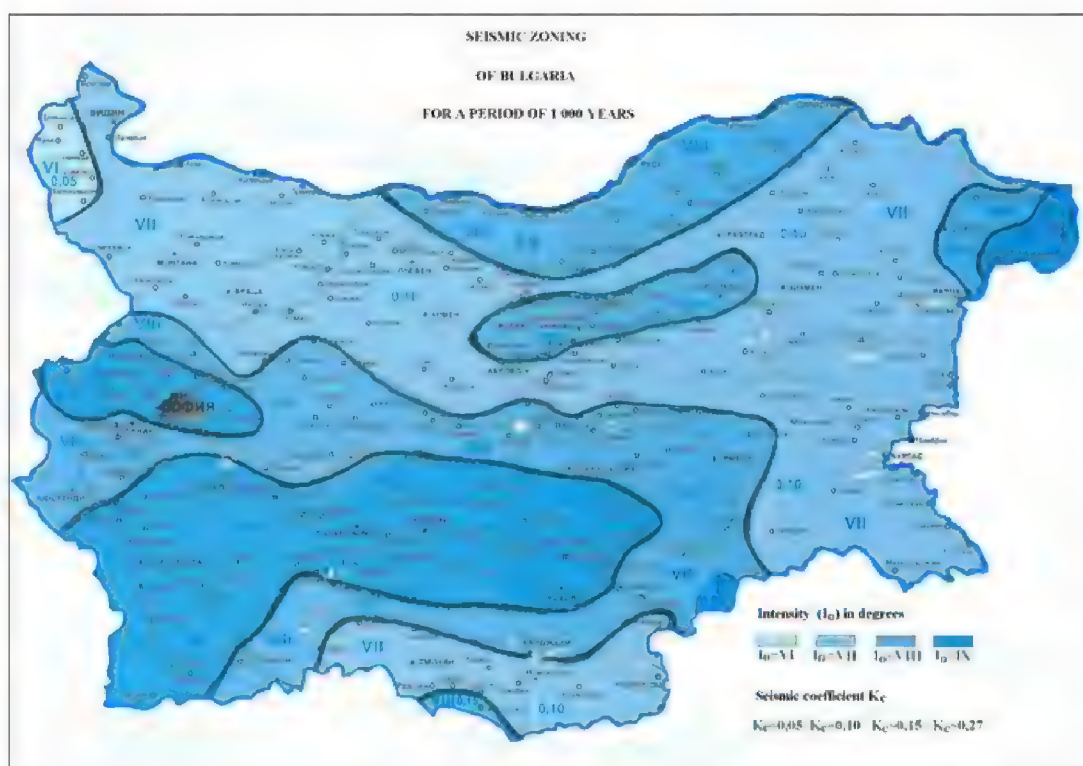
Our native land is a tourist state. The good protection of the cultural monuments represents also a care for national and foreign visitors; it means respect for them.

Especially the safeguarding of the cultural monuments in Sofia and Plovdiv cities represents a very complicated problem as a result of their unfavorable geological position in the mobile tectonic zone of the Sredna Gora. The

situation in Svishtov is more favorable from the point of the local tectonics, but there the influence of the regional movements creates difficulties in the protection of monuments. It is not to be forgotten that we are living over an earthquake-prone land. The earthquakes of the Sredna Gora zone and in Vrancea region (Romania) represent real and potential dangers for the cultural monuments. In a lot of cases this risk is taken into account during the building stages of monuments. To decrease vulnerability of the state's valuables on time, this will become a positive measure to avoid total collapse in the course of time.



**Figure 12.** Svishtov, the Economic College after the 1977 Vrancea earthquake.



**Figure 13.** Seismic zoning of the state [17].

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# SEISMIC ASSESSMENT OF VENETIAN BELL TOWERS: EVALUATION OF VULNERABILITY AT A TERRITORIAL SCALE

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## Introduction

The seismic assessment and risk mitigation of cultural heritage represents one of the principal features for the protection of monumental buildings. If the building history can represent a sort of validation of the structural effectiveness under the ordinary loads, for an extraordinary event (i.e. seismic action), this assumption fails. The physiological and anthropological modifications that have occurred over the centuries, return buildings very different from their original configuration, causing a sort of reset of their structural history.

In relation to this fact, the Italian Ministry of Cultural Heritage and Activities recently set up a reference code [Directive from the President of the Council of Ministers for the seismic-risk assessment and mitigation for cultural heritage, with reference to technical building rules dated 12<sup>th</sup> October 2008] containing the “Guidelines for the seismic-risk assessment and mitigation for cultural heritage” (in the following *Guidelines*). This document provides a methodological guide able to define the seismic safety by attributing a prior role to the knowledge path.

The Guidelines identify three analysis levels characterized by an improvement of the evaluation level. The first level (LV1) is based on a territorial approach of the vulnerability concept. This verification, even if simplified, is able to define a priority list (connected to the seismic risk) of cultural heritage, useful for defining a correct protection planning.

This work refers to the mechanical model LV1 related to “Towers, bell towers and other tall and slender structures”. The model assumes that the structure could be represented as a vertical cantilever beam with the main failure mechanism being governed by combined flexural and axial action. The structural check is applied by comparing the design bending moment with the ultimate flexural resistance, evaluated assuming no-tensile strength for the masonry and an appropriate non-linear distribution of compressive stress.

The verification should be performed according to the two principal axes of the section, relating to different heights, since it is not possible to identify the critical sections beforehand, because of tapering in the wall thickness and weaknesses due to openings.

For this reason the structure should be divided into  $n$  sectors identified by uniform geometrical characteristics, and the check should be performed in correspondence to each section change. The verification related to each section should be calculated according to the two principal axes, since, along the stiffest direction, the fundamental period of vibration is lower and consequently can generate an higher seismic demand.

The design bending moment can be evaluated considering a force distribution, along the height of the structure, congruent with a linear displacement distribution. The force to be applied in correspondence to each sector barycentre is given by the following formula:

$$F_i = \frac{W_i z_i}{\sum_{k=1}^n W_k z_k} F_h \quad (1)$$

where:

- $F_h = 0.85 S_e(T_1) W / qg$  (assuming that the fundamental period of a tower is always higher than  $T_B$ , corresponding to the first point of the peak spectral acceleration plateau);
- $W_i$  and  $W_k$  are the weight of the  $i^{\text{th}}$  and  $k^{\text{th}}$  sector respectively;
- $z_i$  and  $z_k$  are the heights of the barycentre of the  $i^{\text{th}}$  and  $k^{\text{th}}$  sector with respect to the foundation;
- $S_e(T_1)$  is the elastic response spectrum, which is function of the first period of the structure ( $T_1$ ) according to a given direction;
- $W = \sum W_i$  is the total weight of the structure;
- $q$  is the structural performance factor that can be assumed (in absence of a more accurate estimation and according to the building provisions) equal to 3 for the structures with regular shape along the height, or reduced up to 2.25 if obvious stiffness changes along the height or an adjacent building are present;
- $g$  is gravitational acceleration.



The seismic force in the  $i^{\text{th}}$  section is thus given by:

$$F_{hi} = \frac{\sum_{k=1}^n z_k W_k}{\sum_{k=1}^n z_k W_k} F_h \quad (2)$$

The height  $z_{Fi}$ , to which the force  $F_{hi}$  has to be applied, is evaluated through the following formula:

$$z_{Fi} = \frac{\sum_{k=1}^n z_k^2 W_k}{\sum_{k=1}^n z_k W_k} - z_{i*} \quad (3)$$

where:

- $z_{i*}$  is the height of the  $i^{\text{th}}$  section in reference to the base;

By imposing equality between the design bending moment and the ultimate flexural resistance:

$$M_{u,i} = F_{hi} z_{Fi} \quad (4)$$

It is possible to evaluate the lowest return period  $T_{SLV}$  between the different analysis sections, corresponding to the achievement of the life safety limit state (LLS).

In this way it is possible to evaluate a safety index defined as the ratio between the return period of the seismic load and the corresponding reference return period  $T_{R,SLV}$ :

$$I_{S,SLV} = \frac{T_{SLV}}{T_{R,SLV}} \quad (5)$$

Similarly it is possible to evaluate an acceleration factor defined as the ratio between the peak ground acceleration related to the achievement of the LLS and the acceleration corresponding to the reference return period  $T_{R,SLV}$ , both referring to soil type A:

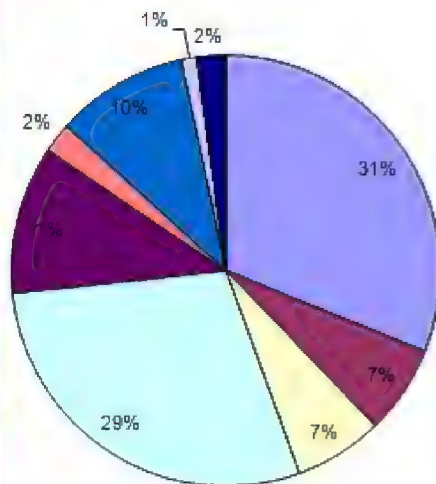
$$f_{a,SLV} = \frac{a_{SLV}}{a_{g,SLV}} \quad (6)$$

### Method applicability

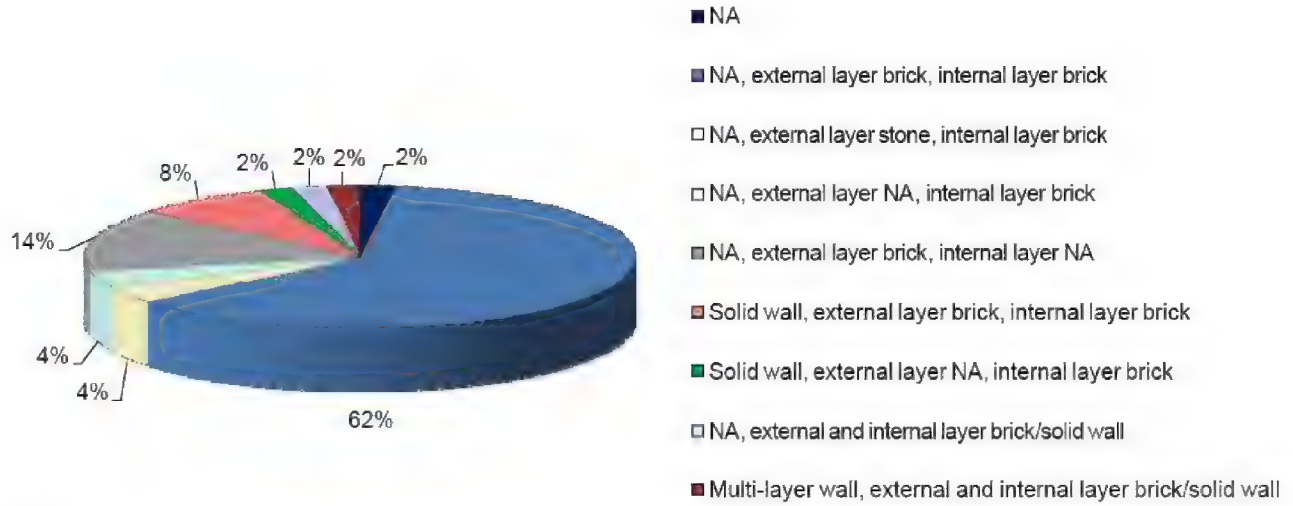
The territorial approach proposed by the Guidelines has been validated with reference to Venetian bell towers. The high number of bell towers (approx. 90) allowed the verification of the possibility of applying the simplified model to a significantly heterogeneous sample, even if grouped by the same category type. The census carried out by the Venice local-board of the Ministry of Cultural Heritage and Activities, permitted the collection of data related to geometrical and dimensional properties, masonry types, belfry shapes and other factors referred to the bell towers sample. This important information, together with limited specific survey, permitted the collation of all the data necessary for the implementation of the mechanical model proposed by the Guidelines.

In order to highlight the heterogeneity of the analyzed sample some statistical distribution related to both the type of roof (Figure 1) and the type of masonry (Figure 2) are shown.

Pitched roof	44	
Dome	6	
Cusp	6	
Tambour and dome	26	
Tambour and cusp	20	
Flat roof	2	
Tambour and pitched roof	9	
Cusp with circular base	1	
Tambour and lowered cusp	2	



**Figure 1.** Statistical distribution of the analyzed sample: roof type



**Figure 2.** Statistical distribution of the analyzed sample: masonry type

In Figure 2 the first label is related to the masonry properties inside the wall thickness: if it is the same type for the whole thickness, if an internal filling layer is present or if it was not possible to survey the data (N.A.). The second label identifies the external layer and the last one the internal in-filled layer (for the most cases it was not possible to evaluate if the in-filled masonry layer properties). The last two types refer to double cross-section bell towers, the first description is related to the external barrel-face and the second to the internal one.

From the statistical analysis it appears that the most common roof-types are characterized by two pitches (31%) or by tambour and dome (26%).

### Application

As highlighted in the §1, the methodology adopted by the Guidelines often needs the knowledge of some parameters which are not immediately available or measurable and for this reason the territorial (cursory) nature of the analysis can be compromised.

Indeed, the survey of the bell towers drift (even if it is not easily measurable in terms of expeditious survey), the evaluation of the fundamental vibration period, the bell tower interaction with adjacent buildings, are essential parameters for the ultimate flexural resistance. For this reason, in the following paragraphs, the authors propose some operative instruments, able to guarantee the effectiveness of results, though preserving the territorial (cursory) nature of a simplified approach.

### Fundamental period assessment

The simplified mechanical model is based on the comparison between the ultimate flexural resistance and the design bending moment, with relation to the principal axes of inertia for the different sections being analysed. The design bending moment is evaluated by assuming a force distribution proportional to the first mode of vibration, which is assumed to be linear. The assessment of the fundamental period is therefore particularly important in order to properly estimate the seismic load acting on the bell tower.

International literature and codes provide many formulations for the estimation of the fundamental period of ordinary buildings, which roughly represent the construction type under examination. The principal formula and the relative code are reported below:

$$T_1 = 0.0217 \cdot H \quad \text{buildings and towers (H > 50 m) [EN 1991 -1-4:2004]} \quad (7)$$

$$T_1 = (0.015 \div 0.018) \cdot H \quad \text{tall RC or mixed buildings [CNR-DT 207/2008]} \quad (8)$$

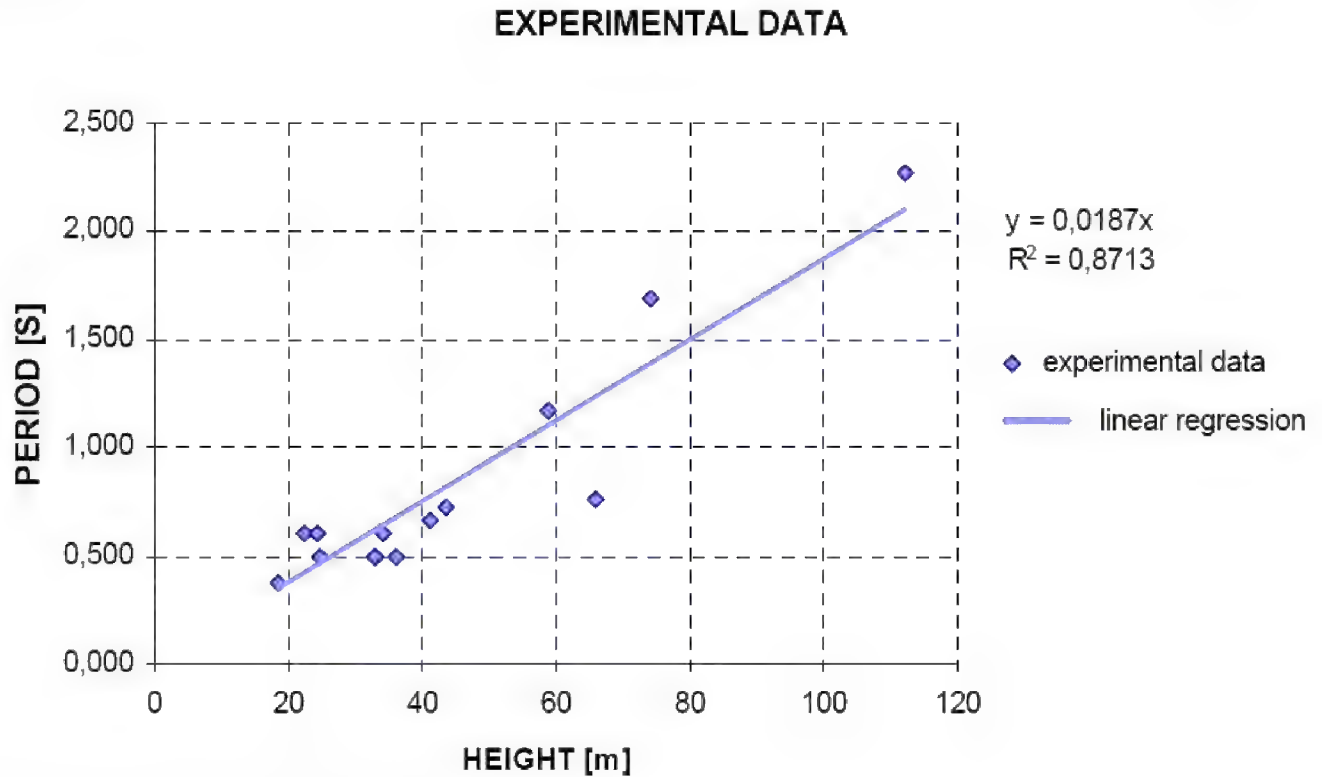
$$T_1 = (0.020 \div 0.024) \cdot H \quad \text{tall steel buildings [CNR-DT 207/2008]} \quad (9)$$

The analysis of the data available from literature, related to dynamic identification of masonry bell towers, permitted the calculation, through the parameterization of data, a good correlation between the measured fundamental frequencies and bell tower height. The linear regression able to better fit the experimental data (Figure 3) is given by the following formulation:

$$T_1 = 0.0187 \cdot H \quad (10)$$

It defines the fundamental period of vibration of a non-cracked section and its results are coherent with the simplified formulations previously quoted.

Figure

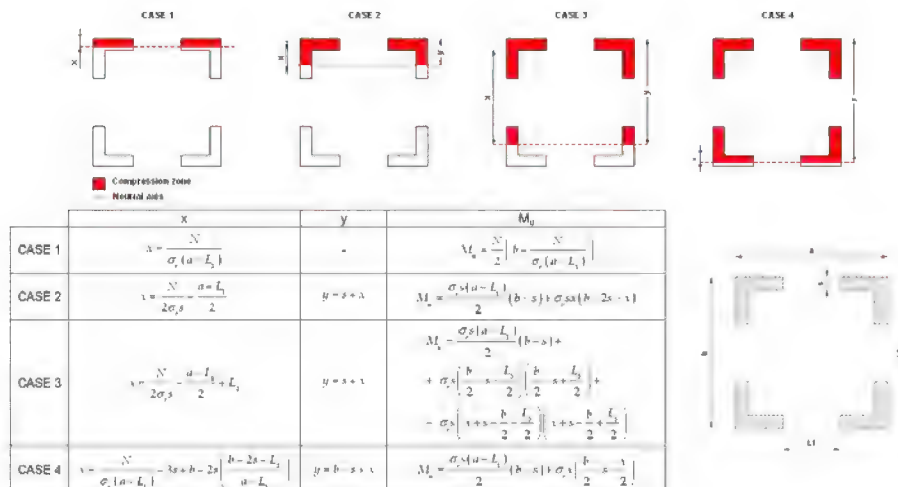


Linear regression of the experimental data

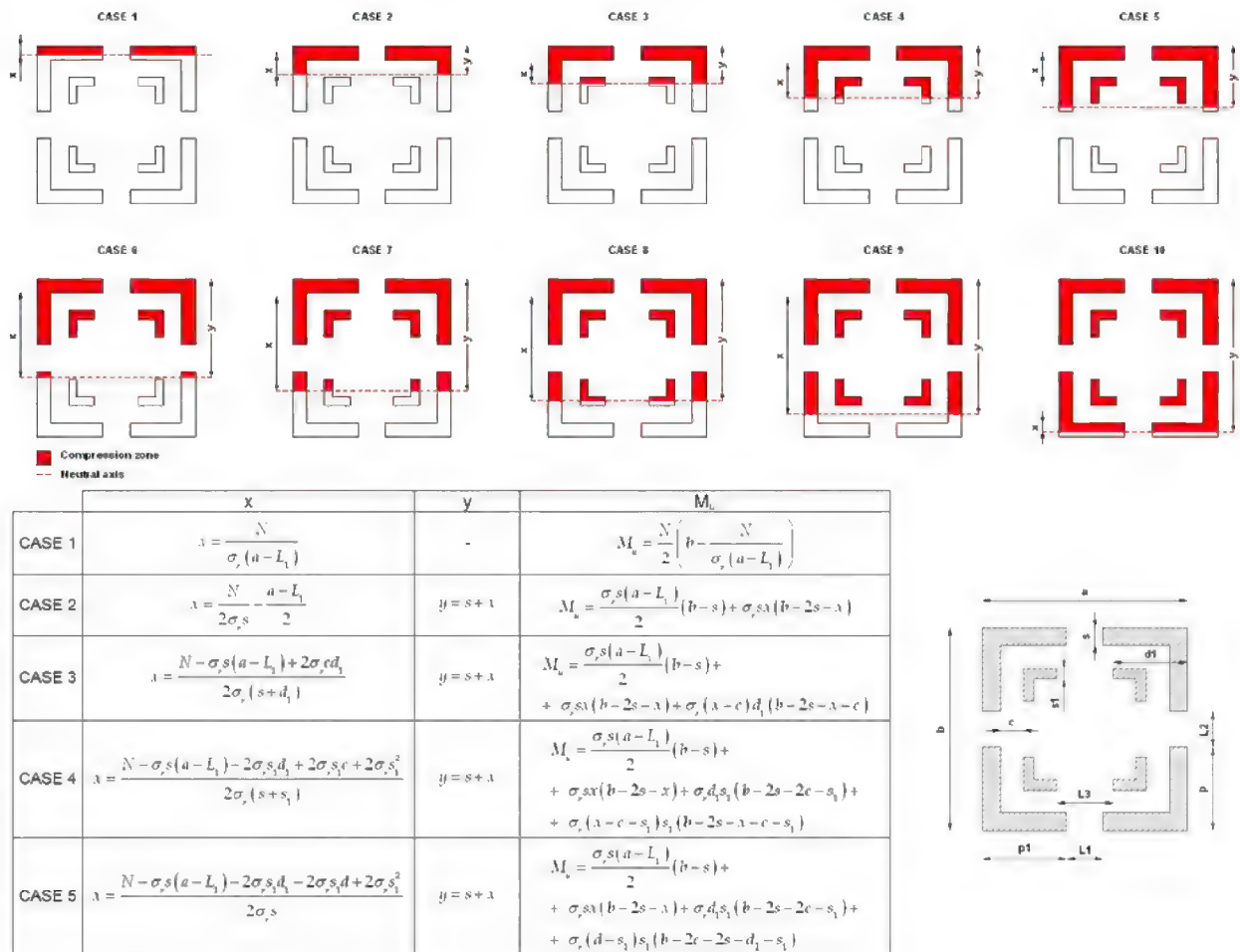
#### Ultimate flexural resistance

The Directive suggests an expression for the evaluation of the ultimate flexural resistance valid for a rectangular single cross-section with openings, in the hypothesis the axial force is assumed to be less than  $0.85 \cdot f_d \cdot s \cdot a$  (where  $f_d$  is the masonry compressive strength,  $s$  is the bell tower walls thickness and  $a$  is the cross-section dimension orthogonal to the seismic load direction, subtracting the openings).

In order to have a general procedure for the evaluation of the flexural resistance, applicable for a generic cross-sectional shape, characterized by a nonspecific opening distribution and for every cracked cross-section configuration, a calculation sheet has been set up in order to determine the ultimate flexural resistance through a numeric procedure. Furthermore generic analytical formulas were devised for single and double rectangular cross-sections, characterized by a symmetric distribution of openings and a generic cracked cross-section configuration. Figure 4 and Figure 5 display the analytical formula for the single cross-section and for some double configurations.



**Figure 4.** Analytical formula for the evaluation of  $M_u$  for a single cross section



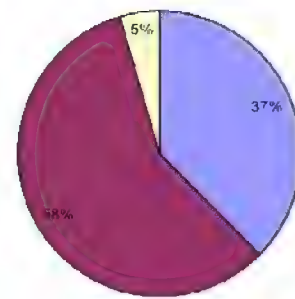
**Figure 5.** Analytical formula for the evaluation of  $M_u$  for a double cross section

### Vertical axis eccentricity

The ultimate moment value is also influenced by possible eccentricities. As it's showed in Figure 7, most of the samples have an high eccentricity of the vertical axis, an emblematic example is the bell tower of S.Martino, in Burano (Figure 6), with a maximum value at the top of the structure of 3.3 m, out of a total height of almost 52 m.



**Figure 6.** San Martino di Burano bell tower



low ( $\alpha < 0.3^\circ$ )	33	
medium ( $0.3^\circ < \alpha < 2^\circ$ )	51	
high ( $\alpha \geq 2^\circ$ )	4	

**Figure 7.** Statistical distribution of the analyzed sample: vertical eccentricity

The presence of vertical eccentricity can be taken into account with a reduction of the ultimate moment of the section, with a secondary moment  $M_s$ , generated by the “non-verticality” of the bell tower (according to the



hypothesis of a linear deformation). The importance of this parameter is summarized in Table 1, in which, for each bell tower, the values (percentage) of the reduction of ultimate moment due to the secondary moment  $M_s$  are reported. This analysis shows how this parameter, even if it's not easily definable, is a considerable aspect that must be taken into account, in particular for those cases in which the eccentricity is visually noteworthy.

	Mu	Ms	Mres	Ms/Mu	vert. ecc.	Htot	vert. /Htot	ecc
	[kN·m]	[kN·m]	[kN·m]	[-]	[m]	[m]	[-]	
S. Martino di Burano	26399	15230	11169	58%	3.34	51.94	6.4%	
S. Francesco Vigna	91081	14218	76863	16%	1.34	75.61	1.8%	
S. Sofia	5174	842	4332	16%	0.733	19.3	3.8%	
S. Stae	26120	7285	18835	28%	1.81	33.37	5.4%	
S. Pietro Castello	56116	13240	42876	24%	1.342	46.26	2.9%	
S.M. Carmini	29605	5318	24287	18%	0.907	45.9	2.0%	
S. Giorgio Maggiore	53734	14341	39393	27%	0.974	67.18	1.4%	

Table 1. Vertical eccentricity effect on ultimate bending moment

### Interaction with adjacent constructions

In case of non isolated bell tower and in absence of details about the link between the tower and the other buildings, the analysis can be carried on with two different verifications:

- 1) the first one considers the bell tower as if it was isolated, hence as if there was no interaction with the surrounding buildings;
- 2) the second, otherwise, considers the different heights of connection with adjacent structures in each direction; actually the constrain offered by the adjacent structure influences the results and the safety index is evaluated considering the seismic behavior of the bell tower as if it started from that level (hence the lower part is considered perfectly fixed).

aggregate on 1 side	9	
aggregate on 2 sides	20	
aggregate on 3 sides	24	
aggregate on 4 sides	11	
added to plant	22	
detached	4	

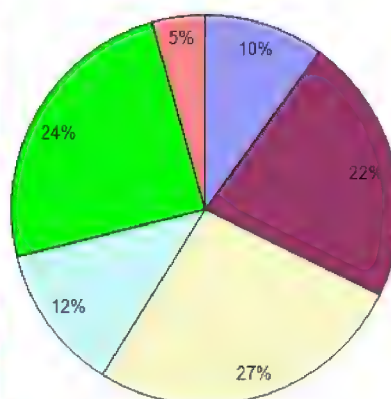


Figure 8. Statistical distribution of the analyzed sample: interaction with adjacent building

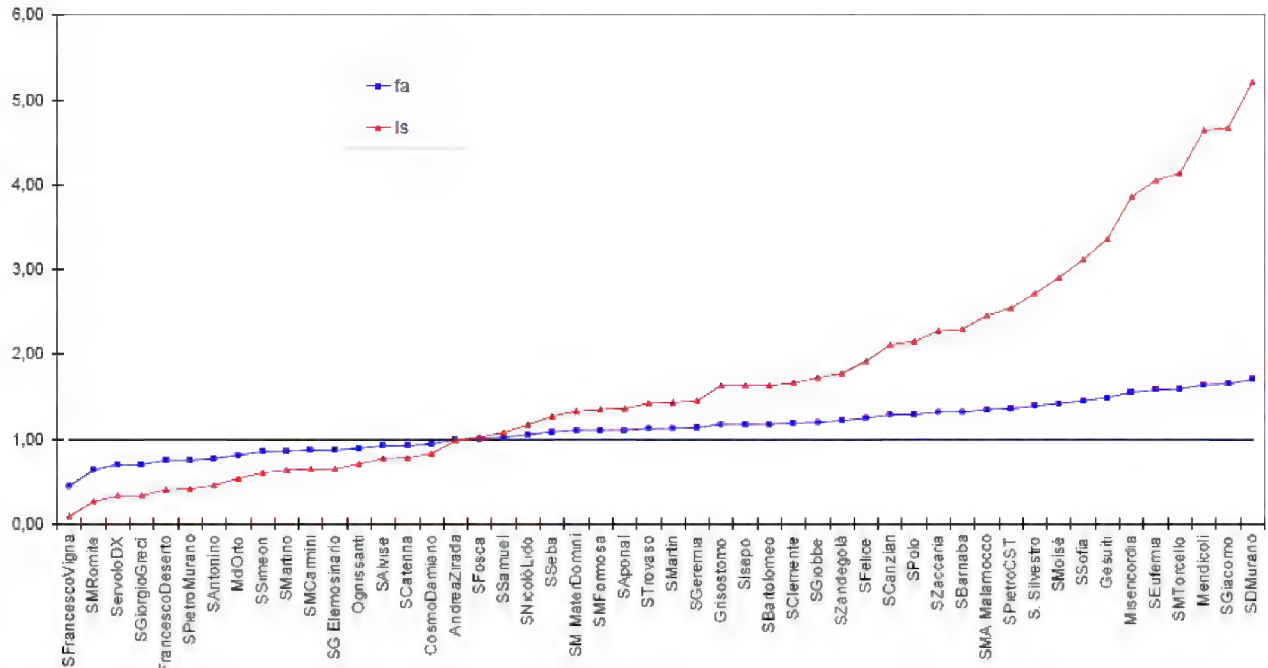
The bearing level is considered as the mean value among the values of the supports of the same wall. Verification as an isolated structure allows to consider the case in which the joint between the two buildings is not enough resistant and that there are no transversal stiff elements at the level of the connection, then in case of seismic event the bell tower oscillates and separates from the other structure. It's clear that this verification cannot take into account the phenomena of hammering; this specific verification must be performed separately, through the use of a more detailed mechanical model. Vice versa the verifications about the bell tower from the bearing level on consider that, in these situations, the tower behaves as a more rigid structure (lower), hence characterized by a lower period of vibration that generally implies a higher seismic action. It is worth noting that, when the bearing levels are very high (i.e. when the free part of the tower subjected to the seismic action is reduced), the experimental formula for the evaluation of the period could not fit the real behavior of the upper part.

### Analysis Results

According with the prescriptions given by Guidelines, harmonized with the ongoing norms (M.D. 14 January 2008) the value of the ratio between capacity of the structure and seismic demand, called acceleration factor  $f_a$ , can be evaluated. This parameter shows quantitatively the lack of the structure in terms of resistance. On the other hand it is

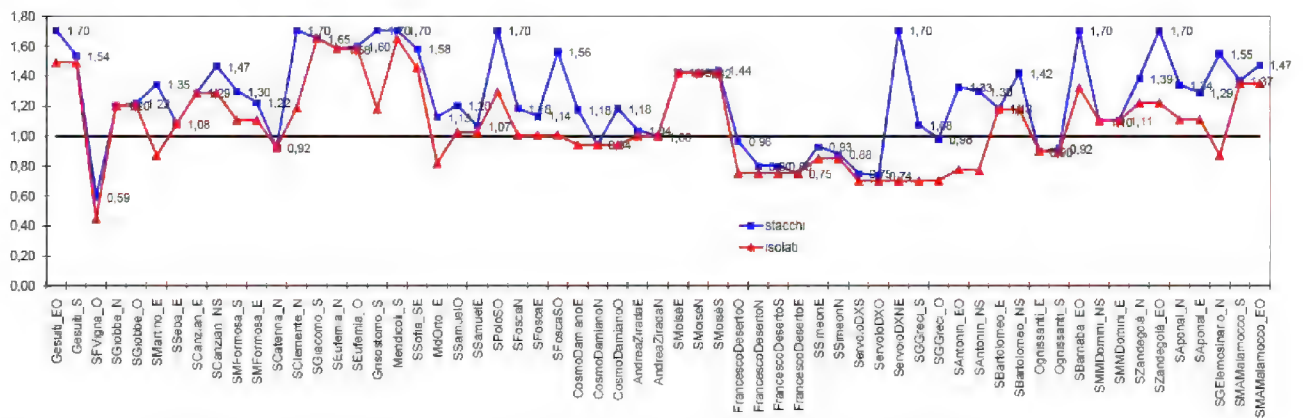
possible the evaluation of the safety index  $I_s$  which is the ratio between the return period of the action that leads to the ultimate state level and the design return period.

Figure 9 shows both the values of  $f_a$  and  $I_s$  for the analyzed structures, within the hypothesis of isolated structure. The values follow the monotonic order of results.



**Figure 9.** Values of  $I_s$  and  $f_a$  for each analyzed bell towers

Figure 10 shows the results in terms of acceleration factor obtained from both the hypothesis of isolated structure and adjacent elements for a sample of 33 towers.

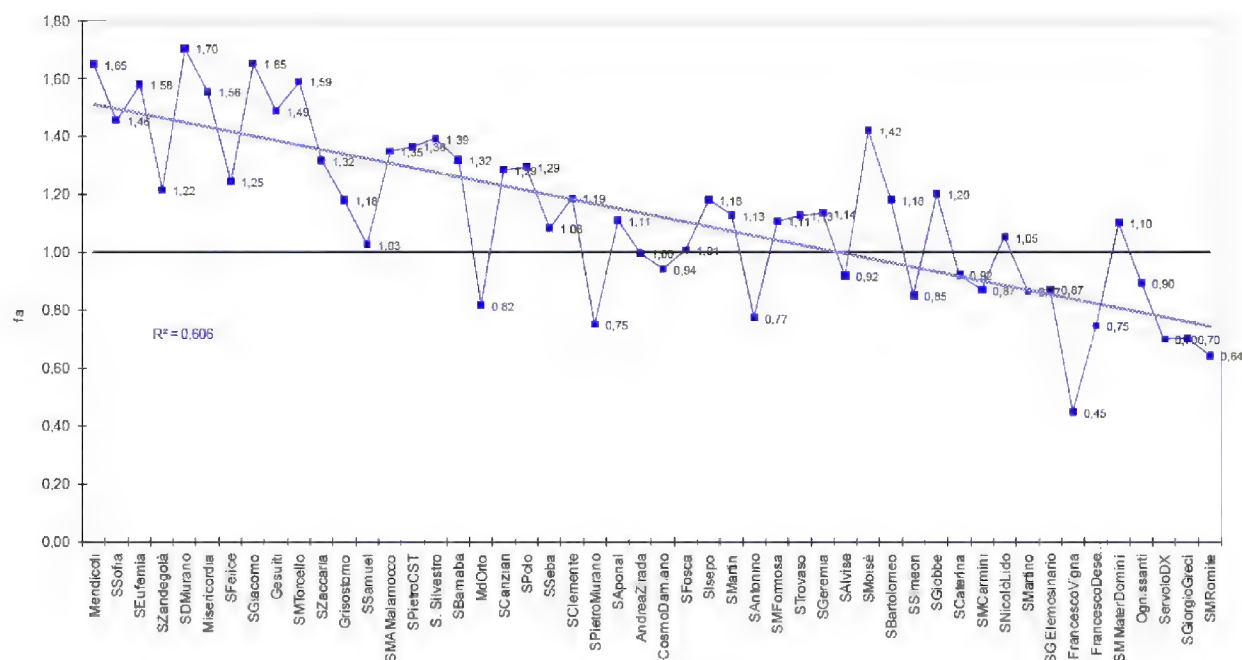


**Figure 10.** Acceleration factor for bell tower as isolated and by considering adjacent elements

Sorting the samples according to increasing height/base ratio (Figure 11) it is possible to underline an intrinsic vulnerability depending on the structural slenderness.

This behavior, which was predictable on the basis of the model assumed, presents some differences mainly due to the following facts:

- it's found a lower peak of the safety index factor for those bell towers which have a high compression stress or a significant vertical eccentricity (i.e. S. Francesco della Vigna, Madonna dell'Orto, S. Antonin, S. Pietro Murano, etc.).
- higher values are found for the isolated towers, due to a higher behavior factor (i.e. Torcello, S. Pietro di Castello, Misericordia, S. Donato Murano).



**Figure 11.** Acceleration factor according to increasing height/base ratio

### Conclusions

The Guidelines give, by means of model LV1, a tool capable to analyze the seismic vulnerability for different typologies of constructions at territorial level. Concerning the mechanical model for “Towers, bell towers and other tall and slender structures”, the case study of Venetian bell towers and the implementation of simplified analytical solutions allowed to highlight the conditions in which this territorial method is applicable and also to draw a ranking of the critical situations from the point of view of the considered collapse mechanism (i.e. failure mechanism governed by combined flexural and axial action).

However, the mechanical model proposed, even if can be considered one of the most significant for slender towers, cannot be considered comprehensive of all the possible failure mechanism of such a structural typology, according also with the recent seismic events occurred in Italy.

Hence it is considered necessary to develop further mechanical models, which should take into account, as an example, the possibility of shear failures, with diagonal cracking, and the mechanisms for the belfry. As for the belfry structural element, the evaluation of the ultimate moment can be performed either considering the hypothesis of plane sections, which considers the section as single, or considering the single walls behaving like frames. In this second case there can be two different interpretations, influenced by the stiffness of the vertical and horizontal elements.

### Acknowledgement

The Authors thank the General Direction of the Italian Ministry of Cultural Heritage and Activities and the Superintendency of Venice, which supported this research.

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## AN INTEGRATE APPROACH FOR THE EVALUATION OF THE SEISMIC SAFETY OF S. MARIA ANTIQUA CHURCH.

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### Abstract

The seismic vulnerability evaluation of monumental buildings cannot prescind from their history often characterized by several transformations. Natural or anthropic events change, in fact, historical buildings respect to the conformation designed by the original builder.

In the case of archaeological site, moreover, the findings, obtained by excavations, have determined, in the past, interventions of completion (e.g. protection of the cultural assets, frescos, statues) restoring buildings different from their original configuration. St. Maria Antiqua church represents, under this point of view, an emblematic case [1]. In order to identify its seismic vulnerability we have studied, firstly, the original structural behaviour through the analysis of the archives data. The church, dismissed at the end of the IX century, was dug at the beginning of XX century, thanks to the excavation campaign coordinated by Giacomo Boni. The knowledge of the vulnerability, that caused the collapse of part of the church, allows us to identify if, for those macro-elements, the seismic vulnerability is still present or if the building structural response can be improved after the retrofiting interventions.

**Keywords:** Seismic risk mitigation; churches; seismic damage and vulnerability

### Introduction

The St. Maria Antiqua church (Figure 1 and Figure 2) is located in the archaeological area of Roman Forum and its first realization can be associated to the “domizianea” age, with a vestibule function of the Imperial Palaces. In the V-VI century the building was transformed in church and this destination was the same until its decay, connected to the severe damage caused by the 847 and the 853 (AD) seismic events [1] [2].



Figure 14. Exterior shots of St. Maria Antiqua church.



Figure 15. Internal shots of St. Maria Antiqua church.



The actual conformation of St. Maria Antiqua church is connected to the work of Giacomo Boni and Antonio Petrucci those who coordinated the excavations since the January 1900. Parallel to the digging activity, Boni and Petrucci began a reconstruction phase that determined, in 100 years, the actual structural conformation associable to a religious building characterized by three naves hall with three different apses [1].

In a recent past, several restoring interventions of frescos were carried out for their degradation. This aspect caused an urgent design of a completion project able to protect the cultural assets from the atmospheric agents. The roof covering system, constituted by wooden trusses, was carried out in 1911, while the vault system of the aisles, rebuilt on the pre-existences, was completed in 1983 by Giuseppe Morganti. The rectangular façade is lower than the central part of the hall. On this part, the actual roof covering has been built with large frontal and lateral openings, in order to re-create the original perception of an open-air.

#### Historical seismic behaviour

The severe damage suffered by the church for the 847 and the 853 (AD) earthquakes (that probably determined the decay of the church) is, partially, confirmed from the damage survey, still now detectable, despite the reconstruction works designed by Boni. The four columns show, in fact, damage modes that can be ascribed to the transversal response of the church (Figure 3) [3]. The cracking for each column is located inwards of the central nave, with material expulsion at the base (e.g.: column on the front-left side (FL) or front-right side (FR) or the back-left side (BL)) or with a rupture at the half height of the shaft as for the column in the back-right side (BR).



a) Column FR: cracking at the base – rocking mechanism. Collapse inwards of the hall; b) Column BR: cracking at the half height of the shaft. Collapse inwards of the upper part of the shaft and outwards of the column base.



a) Column BL: cracking at the base – rocking mechanism. Collapse inwards of the hall - upper part get lost and rebuilt in brick masonry. b) Column BR: cracking at the base. Collapse inwards of the hall - upper part get lost and rebuilt in brick masonry.

Figure 16. Damage ascribed to the transversal response of the church still detectable on the structure.

This hypothesis can be confirmed by the analysis of the archives photos of the different excavation phases, viewed at the Photographic Archive of the Archaeological Superintendency of Rome. It is possible to notice, in fact (Figure 4), as the three columns (BL, FR and BR) collapsed, overturning around the longitudinal axes of the church and as the Boni' replacement is true to reality of the column finding on the ground.



Column BL during the excavation phase



a)



b)

a) Column BR and FR respectively overturned outward for the basement part and inward for whole column; b) Column BR upper part collapsed inward of the hall.

Figure 17. Pictures of the 1900 excavation campaign (Photographic Archive of the Archaeological Superintendency of Rome).

Moreover a meaningful detail, connected to the different slope of the columns, at the moment of their finding, can be observed in the previous images. The columns BL and the upper part of the column BR are with the upper end on the ground. In particular the column BL is horizontal with respect to the ground. This aspect can be correlated to the assumption that the collapse of these elements happened in a moment in which further rubbles were not present on the ground. The column FR is, on the other hand, sloping of rather 60°.

The digging works highlight how the column, when collapsed, settled itself on a sediment which it should be stored for the previous collapses or carried out in the burying works of the church.

The cracking pattern confirms these assumptions. If, as it seems, the severe damage of the church is localized, mainly, in the central part and in the vaults of the aisles, this kind of damage cannot be associated to the longitudinal response of the church. The right side wall is, in fact, frescoed and, although the restoration interventions carried out, shear cracking patterns, common for in-plane action, are not present. The presbyterian collapse of the church have permitted to preserve the apsidal part from the divestment. operations that were carried out, after the seismic events, for the front part as recently proved by a Renaissance excavation where church findings of this part were discovered.

#### Application of mechanical models for historical seismic behaviour analysis

In order to evaluate the seismic vulnerability of the church, connected to the kinematics that can have induced the partial structural collapse of St. Maria Antiqua church after the 847 (AD) earthquake, numerical analyses have been performed through the equilibrium limit method, in compliance with the Guidelines for the evaluation and the reduction of the seismic vulnerability of cultural heritage (Directive PCM 12/10/2007- O.S. n. 25 – O.B. n. 24 – 29/01/2008) [4]. In particular the safety checks have been carried out regarding the linear kinematic analysis (Guidelines – pt. 5.4.3 [4]) described, in details, in the Annex C8A.4 of the Circular n° 617 02/02/2009 – Instructions for the application of the Italian Building Technical Code (M.D 14/01/2008) [5] [6]. With the references of the original historical conformation the collapse mechanisms connected to the transversal response [3] have been studied and, in particular, the kinematics reported in Figure 5 have been analyzed.

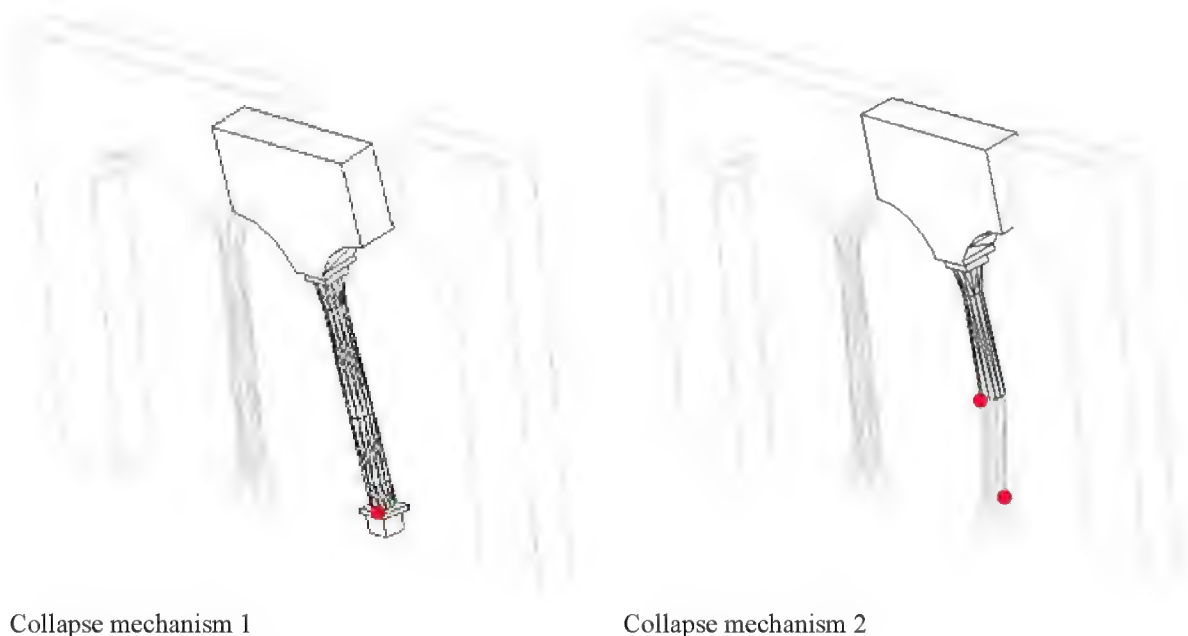


Figure 18. **Collapse mechanisms analyzed for the seismic behaviour study.**

On the basis of the previous considerations, it is, in fact, possible to suppose that the collapse mechanism can be associated to the overturning of the columns inwards of the church (in particular the columns in correspondence of the presbyterian part). Such aspect is connected to the high stiffness of the side walls of the church that avoided an overturning toward the aisles. The collapse mechanisms analyzed are ascribable to two different response: the kinematism 1 is composed by a column that overturns around an hinge located at the base and this mechanism is representative of what can be happened to the columns BL and FR (back-left side and front-right side), while the kinematism 2 is connected to the overturning of the upper part of the column and the consequent overturning of the basement part, outward (analogously for the back right side column BR).

Regarding the seismic action, since, for historical events the real intensity is unknown, we have assumed the seismic input equal to the seismic hazard expected by the actual Italian Technical Code [5] [7], assuming a reference life  $L_R$  equal to 40 years (nominal life  $L_N$  equal to 40 years and a use coefficient  $C_U$  equal to 1), soil condition equal to C and topographic effect equal to  $T_1$  in compliance with the Italian Technical Code [5] (table 1) .



Table 1. Parameters of seismic input.

	LLS	DLS
$a_g$ - peak ground acceleration of the site	1.08 m/s <sup>2</sup>	0.47 m/s <sup>2</sup>
S - soil condition coefficient	1.50	1.50

The verifications have been performed comparing the spectral acceleration  $a_0^*$ , that activated the different collapse mechanisms, with the limit state for the protection of live (ultimate limit state – LLS) and for the damage limit state (DLS), as follows [6]:

$$\text{LLS} \quad \dot{a}_0 \geq \frac{a_{gSLV} \cdot S}{q} \quad [1]$$

$$\text{DLS} \quad \dot{a}_0 \geq a_{gSLD} \cdot S \quad [2]$$

where  $q$  is the behaviour factor equal to 2.

The spectral acceleration  $a_0^*$  has been calculated in compliance with the Circular n° 617 (02/02/2009) [6]:

$$\dot{a}_0 = \frac{\alpha_0 \cdot g}{e^* \cdot F_c} \quad [3]$$

where:

$\alpha_0$  is the activation multiplier of the kinematism calculated through the application of Virtual Works Theorem;

$g$  is the acceleration of gravity;

$e^*$  is the participation mass factor;

$F_c$  is the confidence factor, function of the knowledge level, assumed for the case study equal to 1.24 [4].

In tables 2 and 3 the obtained results are reported with reference to two different limit states.

Table 2. . Linear kinematic analysis results respect to the damage limit state (DLS)

Kinematism	$a_0^*$ [m/s <sup>2</sup> ]	Demand [m/s <sup>2</sup> ]	Verification
1	0.41	0.72	No
2	0.59	0.72	No

Table 3. . Linear kinematic analysis results respect to the ultimate limit state (LLS).

Kinematism	$a_0^*$ [m/s <sup>2</sup> ]	Demand [m/s <sup>2</sup> ]	Verification
1	0.41	0.81	No
2	0.59	0.81	No

In order to obtain a synthetic index representative of the building seismic vulnerability before the 847 and the 853 (AD) earthquakes, the ratios between the capacity of the structure and the demand have been calculated [4] for the collapse mechanism 1. This index has been evaluated with reference to the ultimate limit state (LLS) both as ratio of return periods ( $I_S$  – safety index), and of peak ground accelerations ( $f_a$ ). The results are reported below:

$$I_{S,SLV} = \frac{T_{SLV}}{T_{R,SLV}} = 0.15 \quad [4]$$

$$f_{a,SLV} = \frac{a_{SLV}}{a_{g,SLV}} = 0.51 \quad [5]$$

## Conclusions

The historical analysis and the survey of the cracking pattern of the building have allowed us to perform a possible interpretation of the historical seismic behaviour of the church. This preliminary study is propaedeutic for the seismic safety check of the actual building configuration. In particular, we have identified that the partial church collapse was connected to the activation of a transversal mechanism that involved the 4 central columns. The high



vulnerability of these kinematisms is underlined by the low values of the spectral acceleration of activation and it can be associated to the lack, in the past, of seismic devices able to constrain the upper part of the columns. The actual roof covering play, under this point of view, a fundamental role, because the wooden trusses do not permit horizontal displacements inwards of the church, reducing the vulnerability with reference to a transversal seismic action. The Boni and Petrucci intervention, although it was finalized, mainly, to protect the frescos, reduces, therefore, the original seismic vulnerability.

These considerations highlight how historical damage survey allows to put in evidence those macro-elements characterized, in the past, by high vulnerability. The knowledge of historical structural behaviour permits to focus our attention on these macro-elements and to evaluate if the carried out retrofitting interventions or the suffered transformations, over the years, have mitigated or increased the seismic vulnerability.

### **Acknowledgement**

The authors thank Dr. Giuseppe Morganti (architect of the Archaeological Superintendency of Rome), who supported the research.

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## THE SEISMIC BEHAVIOUR OF THE “SANTI MARCIANO E NICANDRO” CHURCH IN L’AQUILA (ITALY) AFTER THE 6<sup>TH</sup> OF APRIL 2009 EARTHQUAKE.

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**Keywords:** Seismic risk mitigation; churches; seismic damage and vulnerability

### Introduction

Churches, aside from their age and construction style, usually present a higher vulnerability with respect to seismic load. The observation of damage mechanisms which have occurred during past earthquakes in addition to international literature, highlights that the seismic behaviour of churches can be correctly reproduced by subdividing the building into elementary parts characterized by independent structural response (macro-elements) [0], [0], [0], [0]. The strong earthquake that occurred on the 6th of April 2009 in Abruzzo (Italy) led to dramatic consequences both in terms of loss of human life and structural damage. The earthquake effects on monumental buildings, and in particular on churches, were also devastating: According to the damage surveying data collected by the Italian Ministry of Cultural Heritage and Activities, around the 50% of the total amount of the churches located in the L’Aquila province and 95% of the churches located in the L’Aquila historical centre, were unsafe [0].

The “Santi Marciano e Nicandro” church was significantly damaged during the event (**Figure 14**) and the post-seismic surveying highlights that the modifications applied during the previous interventions played a key role in the seismic response.



Figure 19. The “Santi Marciano e Nicandro” church in L’Aquila: damage after the 6th April 2009 earthquake. a) Façade; b) apsidal wall.

The “Santi Marciano e Nicandro” church was founded in 1256 by the castellans from Roio<sup>1</sup> and it was completely reconstructed ten years later when it became a *capoquart*<sup>2</sup> church in accordance with the new subdivision of the centre into four quarters [0]. The thirteenth-century church comprised of a single nave with a transept, including three rectangular vaulted apses; a triumphal arch separated the nave from the transept (Figure 15).

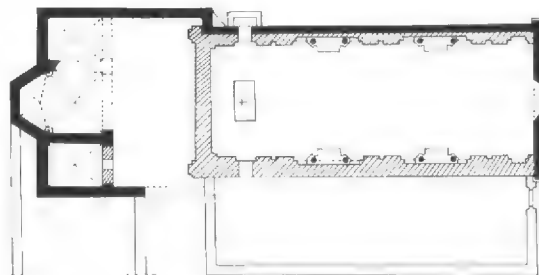


Figure 20. Plan view of the “Santi Marciano e Nicandro” church: thirteenth century configuration (black) and actual configuration (striped).

During the following centuries, the church was embellished both externally and internally and it assumed baroque styling. In 1703 an earthquake nearly destroyed the church, apart from the façade and the lateral walls wainscot.

After the earthquake the hall was reconstructed, and a temporary wall at the back of the triumphal arch was added. The intervention was actually never finished and the apse wall was severely damaged by the 2009 seismic event. New decorations were added to the church interior and in particular a system of paired Corinthian pillars and a decorated plane ceiling were completed. Because of the *capoquarto* role of the church over the centuries, the cultural asset of the church is one of the most precious in the town; after the seismic events the frescos depicting Santa Caterina (XIV century) and the histories of Santi Marciano e Nicandro (Renaissance period) showed a damage increase. The preservation of the cultural assets represents, in fact, one of the most meaningful topics in a vulnerability analysis of cultural heritage.

In this paper the actual damage observed in the “Santi Marciano e Nicandro” church is described and compared with the damage state which can be predicted by using the simplified models proposed in the Italian “Guidelines for seismic-risk assessment and mitigation for cultural heritage, with reference to technical building rules” (G.U. number 24 – 29<sup>th</sup> January 2008) [0].

### The damage surveying

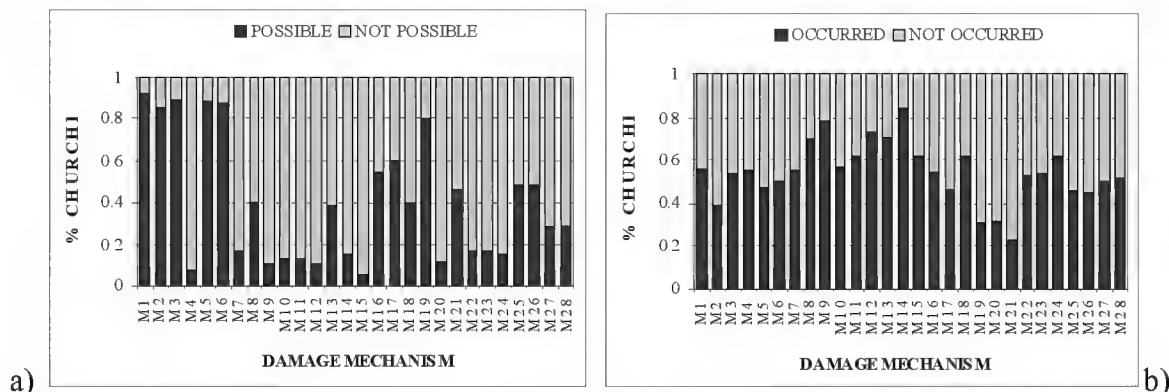
The damage survey during the emergency phase focuses on the evaluation of the building safety, on the definition of temporary supports and on estimating the funds necessary for the restoration and seismic enhancement intervention retrofit. The damage surveying was performed using forms officially adopted by the Ministry of Cultural Heritage and Activities (A-DC Model - G.U. number 55 – 7<sup>th</sup> March 2006, [0]). This methodology proposes 28 damage mechanisms defined as those that occurred most frequently during past earthquakes, thus it aids the operator in defining the possible failure mechanisms for a specific church and the evaluation of the effective damage level related to each mechanism. The mean level of damage of the entire building is represented by an index ( $I_d$ ) which varies between 0 and 1 and is defined as the average of the damage related to different macro-elements:

$$I_d = \frac{1}{5} \cdot \frac{\sum_{k=1}^N \rho_k \cdot d_k}{\sum_{k=1}^N \rho_k} \quad [6]$$

where for every mechanism ( $k$ ):  $\rho_k$  is the weight attributed to the mechanism or to the macro-element (usually equal to 1),  $d_k$  is the level of damage associated to the mechanism (between 0 and 5); and  $N$  is the number of mechanisms that could be activated ( $N \leq 28$ ).

The damage surveying for the “Santi Marciano e Nicandro” church determined a damage index equal to 0.58 and the total number of mechanisms that could possibly occur were estimated to be equal to 11. The low number of possible mechanisms, in relation to the 28 defined for a generic church, highlights an architectural simplicity of the church.

From this point of view, the “Santi Marciano e Nicandro” church, represents an emblematic example representative of a large percentage of Abruzzo churches, statistically characterized by a simple architectural style. The statistical distribution of the possible or impossible mechanisms (Figure 16a) related to the whole sample of the Abruzzo churches surveyed, highlights that religious buildings are usually characterized by a structural simplicity: most of the churches are without aisles ( $M7 < 20\%$ ), transepts ( $M10-M11-M12 < 18\%$ ), lateral chapels ( $M21-M22-M23 < 18\%$ ) or prothyrum ( $M4 < 4\%$ ). Most churches are often without structural vaults ( $M8$ ) or bell towers ( $M27$  and  $M28$ ) which are usually substituted with bell gables ( $M26$ ). This architectural simplicity can be justified by the high level of regional seismic hazard that systematically (with a return period equal to 300 years) tested the Abruzzo monuments. Despite this, the statistical analysis of the activated mechanisms (Figure 16b) confirms the validity of the effort in reducing the seismic vulnerability by looking at simple structural forms, highlighting that the less frequent architectural elements (e.g. domes, vaults) also show medium or high level of damage, just for low macro-seismic intensity.



**Figure 21.** Statistical distribution of the possible (a) and actually activated (b) damage mechanisms for the Abruzzo churches [0].

The damage of the “Santi Marciano e Nicandro” church principally showed the presence of a serious cracking layout associated to a transverse response of the building: the in-plane damage of the façade displayed a level of damage close to collapse and severe cracking was present on the top of the façade; the triumphal arch appeared in particularly critical condition due to the development of a typical kinematism characterized by four plastic hinges; in the apsidal wall grave shear cracking was present as well as in the bell gable. Inside the church critical cracking was located at the mid-high of the side walls, probably in correspondence of a masonry type changing, associated to rocking action due to the transversal response of the nave.

The seismic response of the building in the longitudinal direction, despite the bi-directional input of the seismic event, showed a definite lower level of damage, with only the activation of the mechanisms associated with a high level of vulnerability, i.e. the overturning of the apsidal wall that is completely detached from the triumphal arch and the lateral walls.

The roof was recently restored using a technique applied in many churches in the L'Aquila historical centre (i.e. Santa Maria Paganica, San Biagio ad Amiternum), comprising of the laying of a new reinforced concrete roof on the existing wood trusses, which then carry out the sole function of the ceiling supporting. The roof did not show any damage after the earthquake but it did worsen the out-of-plane mechanisms in the apsidal area.

#### The interpretation of the seismic behaviour of the church.

The “Guidelines for seismic-risk assessment and mitigation for cultural heritage” (G.U. number 24 – 29<sup>th</sup> January 2008 [0]), propose a simplified model (LV1) for evaluating the seismic vulnerability of churches, based on the surveying of some technical details that play a key role in the seismic response of the building, along with the 28 damage mechanisms assumed in the damage survey form (A-DC Model).

The seismic behaviour of the entire building is represented, on a statistical basis, by a vulnerability index which varies between 0 and 1:

$$I_v = \frac{1}{6} \cdot \frac{\sum_{k=1}^{28} v_{ki} - v_{kp}}{\sum_{k=1}^{28} \rho_k} + \frac{1}{2} \quad [7]$$

where for every mechanism (k):  $v_{ki}$  and  $v_{kp}$  are respectively the judgment of effectiveness points obtained for the vulnerability elements (i) and the anti-seismic protection devices (p).

Despite the structural simplicity described in the previous paragraph, the high value of vulnerability index ( $I_v = 0.70$ ) is due to the church modifications during the last centuries (i.e. poor lateral-to-apsidal wall connections; heavy roof).

Starting from the vulnerability index, the model proposed by the Guidelines defines some relations (statistically developed by the damage data observed after past earthquakes) that allow the evaluation of the seismic capacity of the church in relation to a specific limit state ( $a_{SLV}$ ). Consequently the definition of the seismic demand allows the determination of a safety index for the whole building ( $I_s$ ):

$$S \cdot a_{SLV} = 0.025 \cdot 1.8^{5.10 - 3.44 I_v} \quad [8]$$

$$I_s = \frac{a_{SLV}}{a_{g,SLV}} \quad [9]$$

The seismic demand ( $a_{g,SLV}$ ) was defined using two methods: in accordance with the seismic hazard defined by the Italian Technical Standard for Construction 2008 (NTC 2008) [0] for the church site, and in relation to the recorded data gathered by the INGV<sup>3</sup> [0] from the AQK Station which is the closest to the considered site. The comparison between the recorded and code spectra highlights that the seismic event occurred in L'Aquila coherently represents the expected hazard. Analogous results can be achieved by comparing the two safety indexes (Table 1) evaluated by adopting differing seismic demands: Both the values show a low safety level related to the “Santi Marciano e Nicandro” church and underline that the usage of the simplified model for churches could permit an appropriate estimation of the seismic risk during the preventive phase, providing crucial indications relating to the risk mitigation and for designing the seismic enhancement of the building.

Table 4. Safety index values evaluated by using the NTC 2008 and the record during the 6<sup>th</sup> April Earthquake.

	NTC 2008	06/04/09 Earthquake
$I_s [-]$	0.43	0.34



In addition to the application of the simplified model for proposed by Guidelines, a detailed interpretation of the church seismic behaviour was carried out by applying limit equilibrium analysis to the local damage mechanisms actually occurred during the seismic event (Figure 17). The rules given in the 2<sup>nd</sup> February 2009 n° 617 Document “Instruction for the application of the New Technical Code for Construction” [0] were applied. It is possible to observe that the use of the kinematic analysis for the interpretation of the seismic behaviour after an earthquake is particularly effective because the uncertainties related to the geometrical definition of the macro-element, that mainly affect the method reliability during the preventive phase, are not present. In addition to the main damage mechanisms occurred in the “Santi Marciano e Nicandro church” the out-of-plane mechanism related to the façade, that showed a low level of damage, was also considered.



**Figure 22. Collapse mechanisms occurred during the 6<sup>th</sup> April 2009 Earthquake.**

The results related to the linear and non-linear kinematic analysis for the Life Safety Limit State obtained by adopting the recorded seismic spectrum (Table 2) highlight a sufficient agreement with the effective level of damage surveyed after the seismic event: the verifications of the out-of-plane mechanisms related to the two portions of the apsidal wall are fail significantly and the same result is achieved for the in-plane mechanism of the triumphal arch; referring to the façade overturning it is possible to note that, even if the linear kinematic analysis check is not satisfied, the non-linear model permits ensuring the safety of the mechanism.

**Table 5.** Linear and non-linear kinematic analysis results, according to the seismic demand recorded by the AQK-WE INGV Station.

	Linear kinematic analysis			Non-Linear kinematic analysis		
	Spectral acceleration [m/sec <sup>2</sup> ]	Seismic demand [m/sec <sup>2</sup> ]	Check	Displacement capacity [m]	Displacement demand [m]	Check
Out-of-plane overturning mechanism of the façade	1.14	1.64	NO	0.27	0.20	OK
In-plane damage mechanism of the triumphal arch.	1.54	1.74	NO	0.15	0.16	NO
Out-of-plane overturning mechanism of two portion of apsidal wall. Hinge height: 6.1 m.	0.92	1.64	NO	0.08	0.14	NO
Out-of-plane overturning mechanism of two portion of apsidal wall. Hinge height: 11.1 m.	1.41	1.89	NO	0.02	0.08	NO

The use of the seismic demand according to the Italian Code (NTC 2008), during a preventive phase, would have provided accurate results (Table 3). The only exception is the prediction of the in-plane mechanism of the triumphal arch which would not have been adequately represented by linear kinematic analysis. Furthermore it is possible to note that, with the perspective of designing a seismic improvement intervention, the use of the Italian Code would also highlight the need of decreasing the seismic vulnerability of the façade overturning, since the direction of the next seismic event is unknown.

Table 6. Linear and non-linear kinematic analysis results, according to the seismic demand according to the NTC 2008.

	Linear kinematic analysis			Non-Linear kinematic analysis		
	Spectral acceleration [m/sec <sup>2</sup> ]	Seismic demand [m/sec <sup>2</sup> ]	Check	Displacement capacity [m]	Displacement demand [m]	Check
Out-of-plane overturning mechanism of the façade	1.14	1.47	NO	0.27	0.25	OK
In-plane damage mechanism of the triumphal arch.	1.54	1.47	OK	0.15	0.15	NO
Out-of-plane overturning mechanism of two portion of apsidal wall. Hinge height: 6.1 m.	0.92	1.90	NO	0.08	0.14	NO
Out-of-plane overturning mechanism of two portion of apsidal wall. Hinge height: 11.1 m.	1.41	3.45	NO	0.02	0.15	NO

## Conclusions

The 2009 Abruzzo seismic event dramatically confirmed the high vulnerability of historical structures. The damage which occurred in many monumental buildings highlighted the lack of a correct strategy aimed at seismic risk mitigation, can result in the loss of a considerable amount of the cultural heritage. The “Santi Marciiano e Nicandro” church represents, from this point of view, an emblematic example of many Abruzzo churches. The high level of damage that affected the church underlines that a poor attention to the vulnerability can lead to the loss of architectonical and cultural assets.

The application of the instructions provided by the Guidelines for the case study presented in this paper, allows the verification of the accuracy of the legislative tools currently at the councils disposal, can be really effective during the preventive phase for the eventual design of improvement intervention for buildings of worship. Furthermore the simplified model proposed for churches assessed on a territorial level (LV1) effectively interprets the seismic behaviour of this building type.

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#### NOTES

<sup>1</sup> Roio is a small village close to L'Aquila

<sup>2</sup> According to the subdivision of the L'Aquila historical centre into four quarters, the capoquarto churches were the most important of each quarter.

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## **PRELIMINARY ANALYSIS ON THE SEISMIC RISK CONDITIONS OF HISTORICAL BUILDINGS IN L'AQUILA AREA AFFECTED BY EARTHQUAKE ON APRIL 6 2009**

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The disastrous earthquake which affected L'Aquila city and surrounding areas in the night of the 6<sup>th</sup> April 2009, beside causing 300 victims and the destruction of entire villages, also triggered very serious damages to the historic monumental heritage. More than 50 of the most important historical monuments and several buildings, pertaining to "minor" cultural heritage and widespread in the area, were seriously damaged.

As in other seismic events, also in this case, it has been possible to evidence a very strong differentiation on damage distribution. Site effects, energy focusing phenomena and 2D effects have been well documented also by seismic and "vibrometric" monitoring networks which were installed since the first days after the main shock.

If it can partially explain the relevant differences detected on seismic solicitations on the ground and consequently on buildings, it has to be asked why has such a damage level been recorded also on historic buildings subjected to restructuring operations also in recent times.

Taking into account three churches located in Villa S. Angelo village, the Authors present a first analysis on the local seismic response of the sites on which such buildings are and illustrate the obtained results in the light of recent rules about constructions in seismic zone and guidelines on seismic microzoning.



# ESTIMATION OF STRONG GROUND MOTIONS TO EXAMINE EARTHQUAKE-RESISTING CAPACITY OF THE CULTURAL HERITAGE IN IRAN

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## 1. Introduction

Strong ground motions from future large earthquake are predicted at the historic building, Bazaar, in Tabriz, Islamic Republic of Iran in this paper.

Islamic Republic of Iran is a country with frequent earthquakes same as Japan, United States of America, Republic of Turkey, and Taiwan. However, many historic buildings exist in Iran; these buildings were damaged heavily during past large earthquakes. For example, Arge Bam which is a historic building in Bam, south-east of Iran, was destroyed heavily by the strong ground motion during the 2003 Bam Earthquake (Mw: 6.5). The Arge Bam has been repaired under international financial and technical support. The state government aims to register the Bazaar as the UNESCO World Heritage. Many historic buildings, such as Arge Tabriz (Tabriz Castle), Masjede Kabud (Blue Mosque), and Bazaar, exist in Tabriz, north-west of Iran, too. These buildings are brick structures constructed on about AD1400 or AD1500. It's very important to prevent historic buildings against future large earthquakes. Strong ground motion prediction will give basic information to preserve these buildings.

## 2. Outline of Analysis

Strong ground motions are predicted at the historic building, Bazaar (BZR), in Tabriz by using the stochastic Green's function method. This method is very useful to simulate and predict strong ground motions.

The target fault is North Tabriz fault, its whole length is over 200km. The location of North Tabriz fault is decided by Hessami *et al.* (2003). The fault closest distance to BZR is about 2km. The fault is divided to six segments (from segment A to segment F) based on the strike angle. Figure 1 shows location of North Tabriz fault, its segments and target site, BZR. The authors make six fault rupture scenarios, such as a case that only one segment rupture individually occurred and several segments rupture simultaneously occurred. The rupture area and the other parameters of each scenario are shown in Table 1 and Figure 2. The moment magnitude of each scenario is in the range from 6.6 to 7.9. The Outer and inner fault parameters are given according to the recipe for predicting strong ground motions from future large earthquakes proposed by Irikura *et al.* (2004). For example, the fault parameters of scenario No.2 is shown in Table 2. Figure 3 shows the location of asperities and rupture starting points of scenario No.2. Fault slip displacement in asperity area is greater than that in other area; more rupture energy is generated from asperity area. The largest asperity is located nearest area to BZR in each case. This location is the worst case for the target site. Several points are given as rupture starting points and the parametric study is done. For example, seven points are given as rupture starting points in scenario No.2 (from R1 to R7).

Damping factor on seismic propagation path route, Q-factor, is evaluated by spectral inversion analysis proposed by

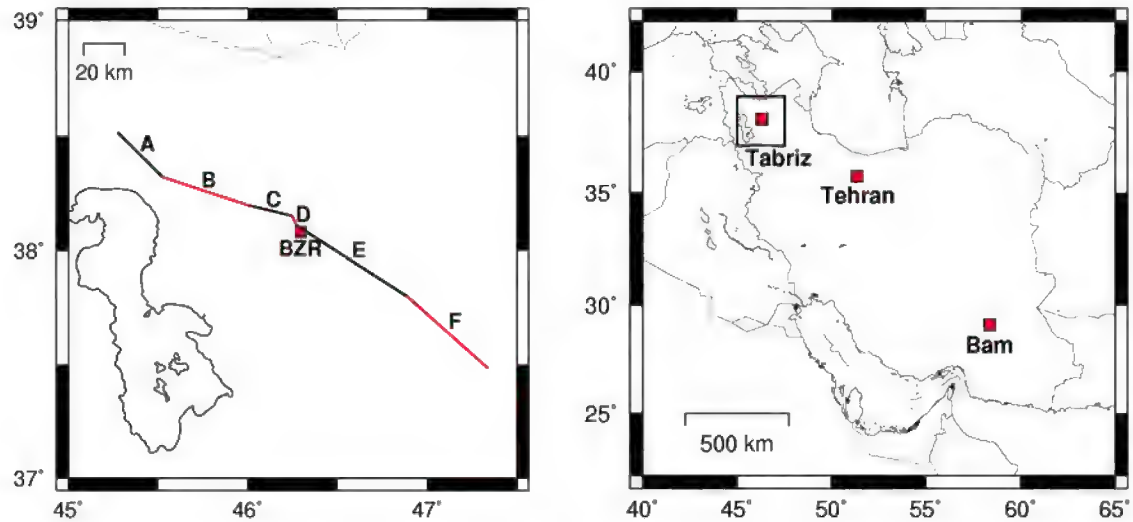


Figure 1. Location of target fault and target site (BZR)

Table1. Rupture area etc. of each scenario

Scenario No.	No.1	No.2	No.3	No.4	No.5	No.6
Rupture Area	Seg. C	Seg. E	Seg. C Seg. D -	Seg. D Seg. E -	Seg. C Seg. D Seg. E	All Seg.
Length (km)	22	64	28	70	92	218
Width (km)	18	18	18	18	18	18
Area (km <sup>2</sup> )	396	1,152	504	1,260	1,656	3,924
Seismic moment (N·m)	$8.72 \times 10^{18}$	$7.38 \times 10^{19}$	$1.41 \times 10^{19}$	$8.83 \times 10^{19}$	$1.53 \times 10^{20}$	$8.56 \times 10^{20}$
Moment magnitude	6.6	7.2	6.7	7.2	7.4	7.9

Iwata and Irikura (1983) using observed records of four small earthquakes at three sites. Q-factor is obtained as a function of frequency shown in Equation (1).

$$Q(f) = 17.4 \times f^{1.00} \quad (1)$$

where,  $f$  is frequency.

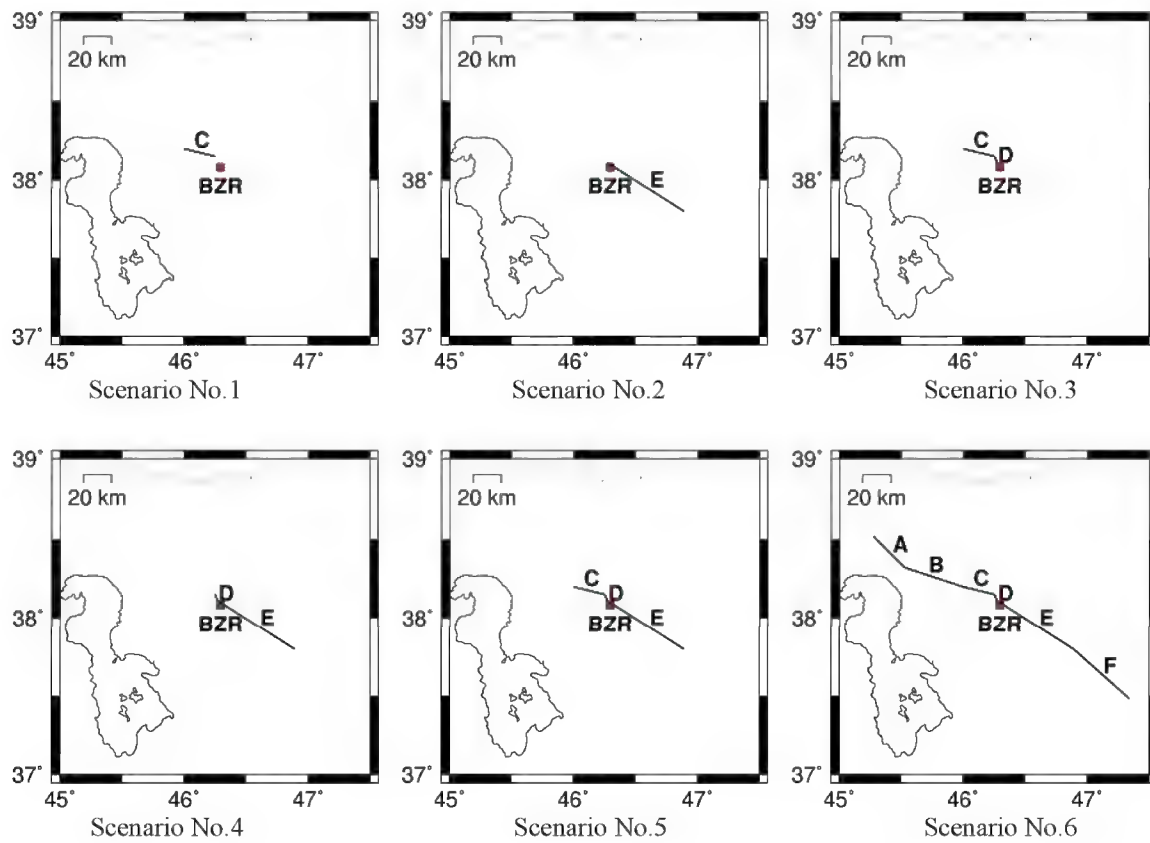


Figure 2. Fault rupture scenarios

Table2. Outer and inner fault parameters of scenario No.2

Outer fault parameters		Inner fault parameters	
Upper depth (km)	2	Asperity 1	
Lower depth (km)	20	Area (km <sup>2</sup> )	280
Fault length (km)	64	Moment (N·m)	$3.99 \times 10^{19}$
Fault width (km)	18	Slip (cm)	430.8
Fault area (km <sup>2</sup> )	1152	Stress drop (MPa)	12.5
Strike angle (°)	122.4	Asperity 2	
Dip angle (°)	90	Area (km <sup>2</sup> )	144
Rake angle (°)	172	Moment (N·m)	$1.47 \times 10^{19}$
Seismic moment (N·m)	$7.38 \times 10^{19}$	Slip (cm)	308.9
Moment magnitude	7.2	Stress drop (MPa)	12.5
Average slip (cm)	193.7	Off-asperity area	
Average stress drop (MPa)	4.6	Area (km <sup>2</sup> )	728
		Moment (N·m)	$1.92 \times 10^{19}$
		Slip (cm)	79.8
		Stress drop (MPa)	2.5

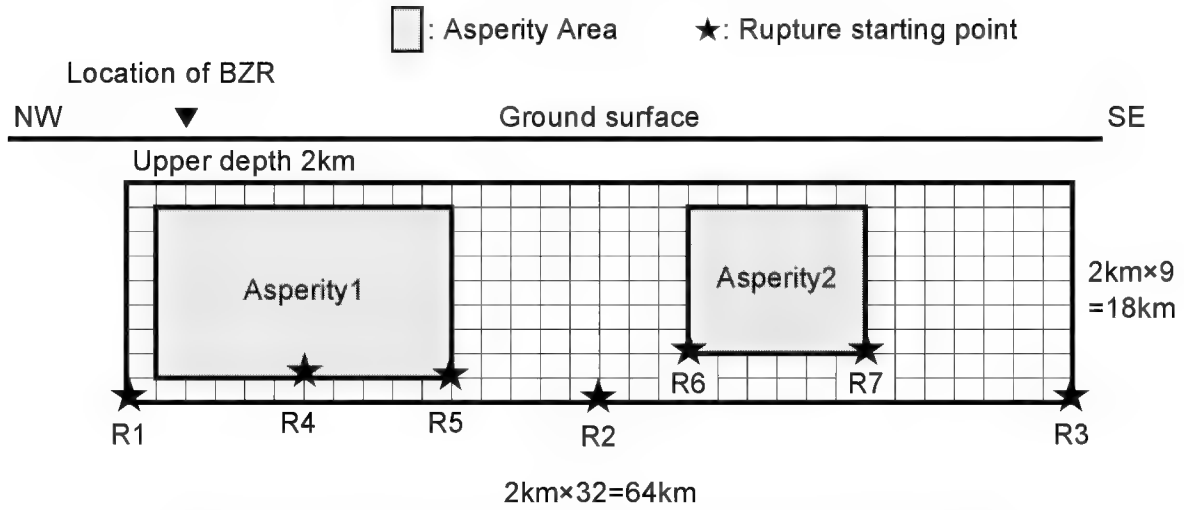


Figure 3. Location of asperities and rupture starting points of Scenario No.2

Site amplification factor,  $G$ , is evaluated by very simple method using density and S-wave velocity of ground surface and seismic bedrock such as Equation (2). 4.8 is used as a site amplification factor that is not depended on frequency in the prediction.

$$G = \sqrt{\frac{\rho_1 \times V_{S1}}{\rho_2 \times V_{S2}}} \quad (2)$$

where,  $\rho_1$  and  $\rho_2$  are density of seismic bed-rock and ground surface ( $2.8\text{g/cm}^3$  and  $1.8\text{g/cm}^3$ ), and  $V_{S1}$  and  $V_{S2}$  are S-wave velocity of seismic bed-rock and ground surface ( $3,000\text{m/s}$  and  $200\text{m/s}$ ).

The high-cut filter,  $P(f)$ , shown in Equation (3) is adopted in the prediction. The filter is evaluated by the observed records during the 2005 Fukuoka-ken Seiho-oki earthquake [Tsurugi *et al.* (2008)].

$$P(f) = \frac{1}{\sqrt{1 + \left(\frac{f}{6.5}\right)^{2 \times 0.90}}} \quad (3)$$

### 3. Results

Figures 4 show predicted acceleration waveform and Figure 5 show response spectra (Damping: 5%) of predicted motions for the fault rupture scenario No.2. The fault rupture scenario No.2 is case of only one segment which is the nearest segment to the BZR, segment E, ruptures individually. The fault length is 64km and seven points are given as rupture starting points (from R1 to R7). The observed record at Bam during the 2003 Bam earthquake is shown in the figures, too. The observed record of N008E component at Bam is drawn as NS component and N278E component is drawn as EW component in these figures. The peak ground accelerations are estimated in the range from  $760\text{cm/s}^2$  to  $1,400\text{cm/s}^2$ . The predicted motions at BZR are greater than the observed record at Bam during the 2003 Bam earthquake.



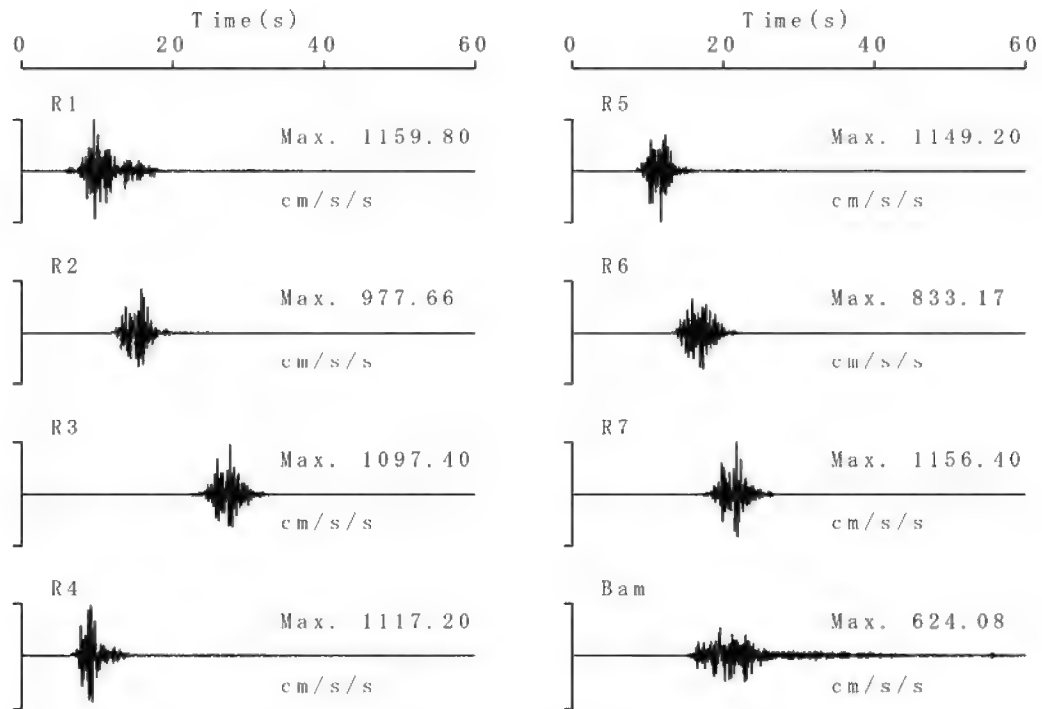


Figure 4. Predicted acceleration waveform and observed record at Bam (NS Component)

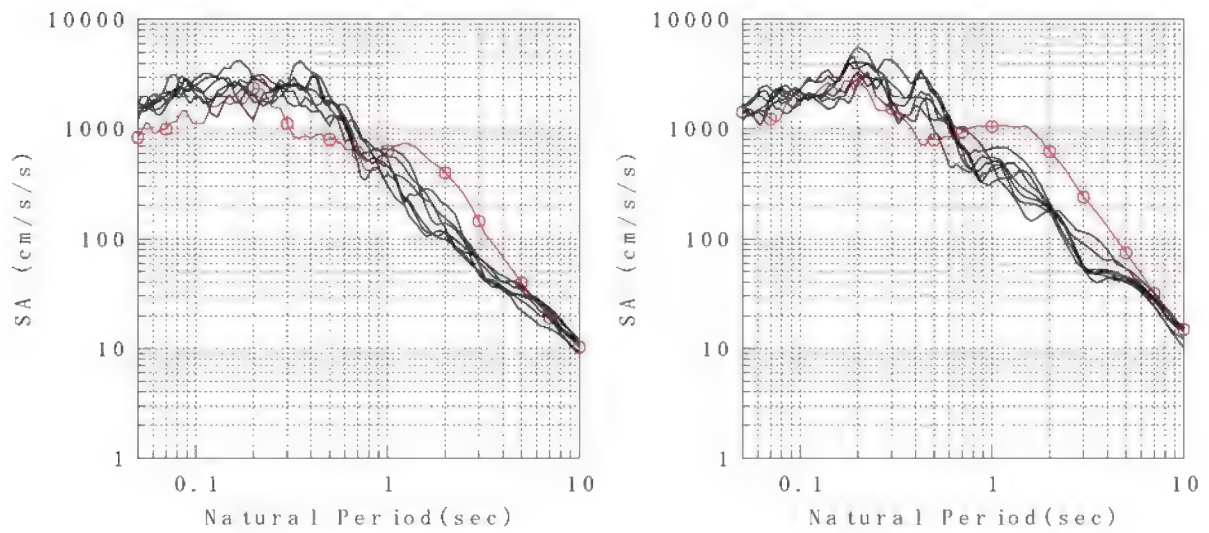


Figure 5. Response spectra of predicted motions (Left: NS Comp., Right: EW Comp.)

#### 4. Conclusion

Strong ground motions from future large earthquake are predicted at the historic building, Bazaar, in Tabriz, NW Iran by the stochastic Green's function method. Target fault is North Tabriz fault, its whole length is over 200km. The fault parameters are given according to the recipe for predicting strong ground motions from future large earthquakes. The predicted motions at Bazaar are greater than the observed record at Bam during the 2003 Bam earthquake. If the North Tabriz fault will rupture, heavy damage will be predicted. The predicted strong ground motions will be very useful to examine earthquake-resisting capacity of historic building.

The site amplification factor which is evaluated by very simple method is used in this prediction. We will estimate the site amplification factor by accurate method such as evaluating by one-dimensional ground structure model based on the result of PS logging test or empirical method using observed seismic records.

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## SEISMIC PROTECTION OF HISTORICAL BUILDINGS: THE PROHITECH PROJECT

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### Abstract

This paper is an overview of the PROHITECH research project, which has been focused on the seismic protection of historical buildings, typically those dating back from the ancient age up to the mid of the 20th Century, belonging to the Euro-Mediterranean area. The main objective of the project consisted of the development of sustainable methodologies for the use of Reversible Mixed Technologies (RMTs) in the seismic protection of existing constructions. The research program has involved 16 academic institutions coming from 12 Countries mostly belonging to the South European and Mediterranean area. The research activity, both theoretical and experimental, has been accomplished with a proposal of codification for the use of RMTs in the seismic protection of existing constructions, which meets the most up-to-dated codification issues at European level and complies with layout, language and philosophy of structural Eurocodes.

### Introduction

The Mediterranean and Balkan regions are greatly exposed to seismic hazard, which results in the built heritage of these areas to be strongly susceptible to severe damage or even collapse in case of earthquake. Constructions most at risk are the historical and monumental ones, since in many cases they are not endowed with basic anti-seismic provisions and/or no seismic retrofit has been applied to them. In this field, the intervention methods must be not only reliable and durable, but also, if required, easy to monitor and remove, the latter aspect corresponding to the widely shared policy of safeguarding existing buildings from inappropriate restoration interventions, with particular reference to historical and monumental constructions. At the same time, modern constructional systems have provided good seismic performances, strongly limiting damage and avoiding collapse. This has been recognised not only for new buildings, but also in the seismic rehabilitation of existing buildings, with significant examples in the field of historical and monumental constructions (Mazzolani 2005, 2006a,b, 2007a,b, 2008a,b, 2009a, b).

The EC funded research project PROHITECH "Earthquake Protection of Historical Buildings by Reversible Mixed Technologies" is framed within the INCO thematic areas INCO-B.2, INCO-2002-B2.1 and INCO-2002-B2.2 of the Sixth Framework Programme, devoted to "Protection and conservation of cultural heritage" in the Mediterranean area. The main objective of the project was the development of sustainable methodologies for the use of Reversible Mixed Technologies (RMTs) in the seismic protection of the existing constructions. Sixteen academic institutions, coming from twelve Countries mostly belonging to the South European and Mediterranean area, have been involved in the research programme (Fig. 1).



**Figure 1.** The partner countries involved in the PROHITECH project.

The partner countries have been: Algeria (AL), Belgium (B), Egypt (EG), Macedonia (MK), Greece (GR), Israel (ISR), Italy (I), Morocco (M), Portugal (P), Romania (RO), Slovenia (SL), Turkey (TR).

RMTs exploit the peculiarities of innovative materials and special devices, allowing ease of removal when necessary. At the same time, the combined use of different materials and techniques yields an optimisation of the global behaviour under seismic actions. This proves to be an important feature since the cultural importance of historical constructions limits, in many cases, the possibility to upgrade them from the seismic point of view, due to the fear of using intervention techniques which could have detrimental effects on their cultural value. The activity of PROHITECH has

been concerned with both experimental tests and numerical analyses, together with a number of case studies and a proposal of codification. This paper is an overview of such research project, which has been focused on the seismic protection of historical buildings belonging to the Euro-Mediterranean area and dating back from the ancient age up to the mid of the 20th Century. The description is concentrated on experimental and numerical activity, which represent the outstanding result of the project as well as the most significant achievement in terms of innovation.

## 2 THE EXPERIMENTAL ACTIVITY

Experimental tests maybe represent the actual core of the PROHITECH research project, they having provided a very important contribution in the development of Reversible Mixed Technologies for the application in the seismic protection of historical buildings. The experimental activity has been carried out at five different levels, namely full scale tests, large scale models, sub-systems, devices, materials and elements.

The full scale experimental tests have been referred to the following constructions: a reinforced concrete building located in the Bagnoli area in Naples, Italy (Fig. 2); the Mustafa Pasha Mosque in Skopje, Macedonia (Fig. 3); the Gothic Cathedral in Fossanova, Italy (Fig. 4); the Byzantine St. Nikola Church in Psacha, Kriva Palanka, Macedonia (Fig. 5); the Beylerbeyi Palace in Istanbul, Turkey (Fig. 6). The experimental studies on the Bagnoli r.c. building have been extremely exhaustive and detailed, since this building is not an “ad hoc” built model but it is a “real” construction, actually representative of a large part of the building stock erected in many Countries during the 20th Century. For this reason it has been a unique occasion of knowledge deepening. After preliminary tests on materials, aimed at their characterization from the mechanical point of view, the dynamic identification of the structure has been performed (Mazzolani et al., 2005). Inelastic cyclic tests under lateral loading conditions, with the possibility to alternately push and pull the construction up to reach pre-fixed horizontal displacement values, have been carried out. The experimental tests have been divided in three phases. In the first phase, the original structure has been strongly damaged by applying a seismic input corresponding to a return period of more than three thousand years (Fig. 7). In the second phase, it has been repaired by means of FRP bars placed in the mortar joints of the external walls (Fig. 8a) and damaged again (Della Corte et al., 2008). At last, in the third phase, an intervention by means of buckling restrained braces (BRBs) has been applied (Fig. 8b), with subsequent further tests (D’Aniello et al., 2007). The full scale experimental work on the other above mentioned buildings, say the Mustafa Pasha mosque, the Gothic Cathedral in Fossanova, the St. Nikola Church in Psacha, Kriva Palanka, and the Beylerbeyi Palace in Istanbul, have been non-destructive tests, mainly focused on the characterization of the structural materials as well as on the dynamic identification of the constructions.

The programme of large scale tests has included experiments on the following models: Mustafa Pasha Mosque; Fossanova Gothic Cathedral; Greek Temple; St. Nikola Byzantine Church in Psacha. The 1:6 scale model of the Mustafa Pasha Mosque has been realized at the IZIIZ Laboratory in Skopje (Fig. 9a). The main objective of the experimental investigation has been the study on the effectiveness of the proposed reversible intervention, based on the use of C-FRP elements. The experimental campaign on the Mustafa Pasha Mosque model has been carried out in three main phases (Krstevska et al. 2007; Landolfo et al. 2008). During the first phase, the model has been subjected to low intensity seismic inputs, in order to damage the minaret only. In the second phase, after the consolidation of the minaret by C-FRP elements (Fig. 9b), larger seismic inputs, corresponding to the Petrovac earthquake (Montenegro, 1979) have been applied, in order to assess the effectiveness of the intervention on the minaret and to severely damage the mosque, whose dome has been seriously cracked. In the third phase, in which the minaret has been removed due to safety requirements, the mosque model has been consolidated (Fig. 9c) and has been subjected to larger seismic inputs. The adopted intervention has proved to be very effective, so that it has been selected by local Authorities for the consolidation of the real mosque, currently ongoing (Mazzolani et al., 2009). The 1:5.5 scale model of the Fossanova Gothic Cathedral has been tested at the IZIIS Laboratory (Fig. 10a). Shaking table tests have been carried out on the Fossanova model both before and after the consolidation, obtained by means of FRP cables. After the test on the original construction, which has induced damage, the model has been repaired and post-tensioned FRP cables, both horizontal and vertical, have been applied (Fig. 10b). The consolidated model has then been subjected to two tests, in which the vertical cables were always active: a first test, with only the superior horizontal cables active; a second test, with all the horizontal cables active. The used intervention has increased the seismic resistance of the structure of about three times. With regard to the tests on the large scale models of a Greek temple (scale 1:3 with respect to the columns of Parthenon), several experiments have been conducted on the shaking table of the Earthquake Engineering Laboratory of the National Technical University of Athens (NTUA), namely experiments on three freestanding columns in a row (Fig. 11a), experiments on three columns in a row with architraves (Fig. 11b) and experiments on columns in corner (Fig. 11c). Shaking table tests both before and after the consolidation by means of metallic clamps have been carried out, showing the effectiveness of such systems in the seismic protection of Greek temples. At last, the 1:3.5 scale model of the St. Nikola Byzantine Church (Fig. 12) has been tested on shaking table at the IZIIS Laboratory. A first test on the base isolated model, by means of the ALSC floating-sliding system, has been carried out. The protection system has performed adequately, avoiding the model to be damaged. A second test, in which the seismic isolation has been removed, has led to severe damage in the construction.

Many experimental tests on sub-systems have been carried out, they being mainly related to the application of RMTs to masonry, timber, reinforced concrete and iron structures. With regard to masonry panels, two main groups of experiments have been carried out. The first group, at the “Politehnica” University of Timisoara (Romania), has dealt with the behaviour of masonry panels consolidated by means of metal (steel or aluminium) sheeting plates or steel wire



mesh, applied at the external faces of the panel. In this case, the connection of the metal sheet plates to the masonry wall can be made in two ways, namely by means of chemical anchors or pre-stressed ties; the wire mesh is glued to the masonry wall by using epoxy resin. The second group, at the University of Naples “Federico II” (Italy), has dealt with the behaviour of masonry walls strengthened by FRP bars, located in the mortar joints. These tests have been aimed at investigating the behaviour of such masonry walls in three conditions, namely in absence of the retrofitting system, in presence on the FRP bars at one side of the wall only, and in presence of the FRP bars placed at both sides of the masonry wall.



**Figure 2.** The reinforced concrete building for the full scale tests in Naples, Italy.



**Figure 3.** Mustafa Pasha Mosque in Skopje, Rep. of Macedonia.



**Figure 4.** The Gothic Cathedral in Fossanova, Italy



**Figure 5.** St. Nikola Church in Psacha, Kriva Palanka, Rep. of Macedonia.



**Figure 6.** The Beylerbeyi Palace in Istanbul, Turkey.



**Figure 7.** Damage in the full scale building after the test on the original structure.

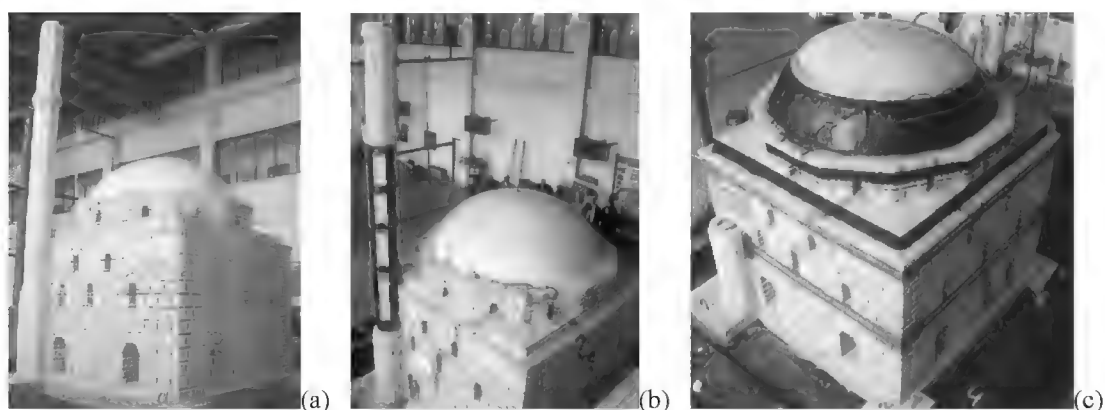


(a)

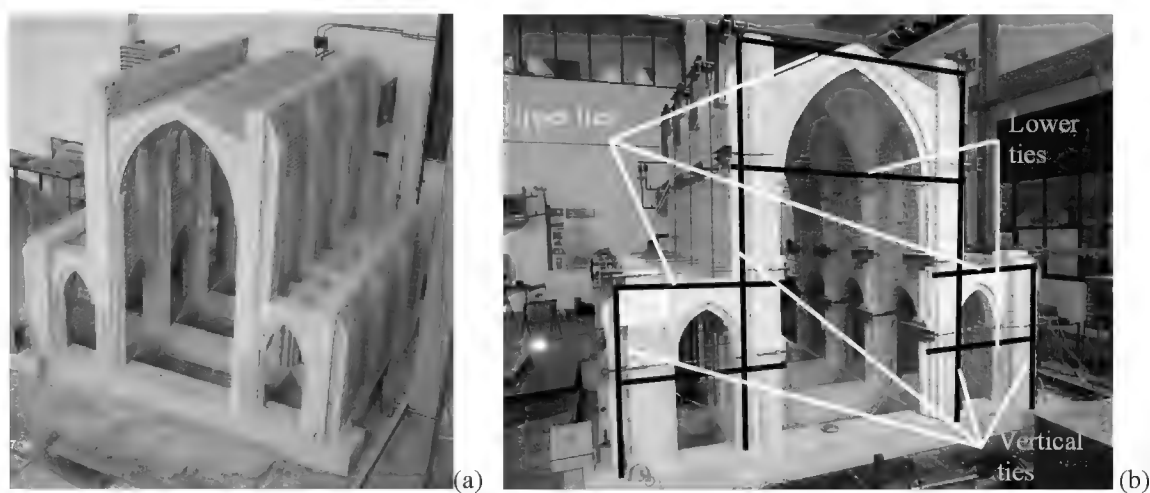


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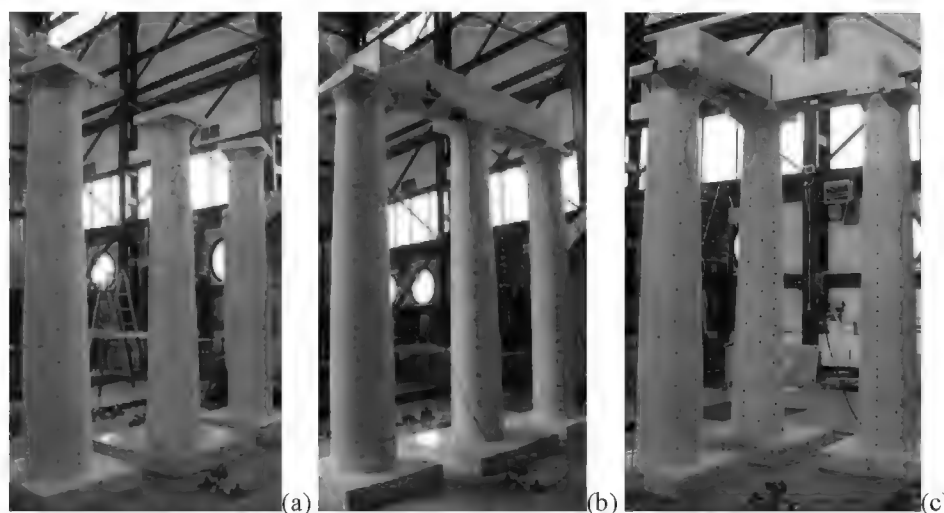
**Figure 8.** Repair interventions in the r.c. building: (a) by means of FRP bars; (b) by means of BRBs.



**Figure 9.** The 1:6 scale model of the Mustafa Pasha Mosque: (a) before the tests; (b) after the minaret consolidation; (c) after the mosque consolidation.



**Figure 10.** The 1:5.5 scale model of the Fossanova Gothic Cathedral: (a) before the tests; (b) the consolidation intervention.



**Figure 11.** The 1:3 scale models of Greek temple columns in three configurations: in a row (a) without and (b) with architrave; (c) with columns in corner.

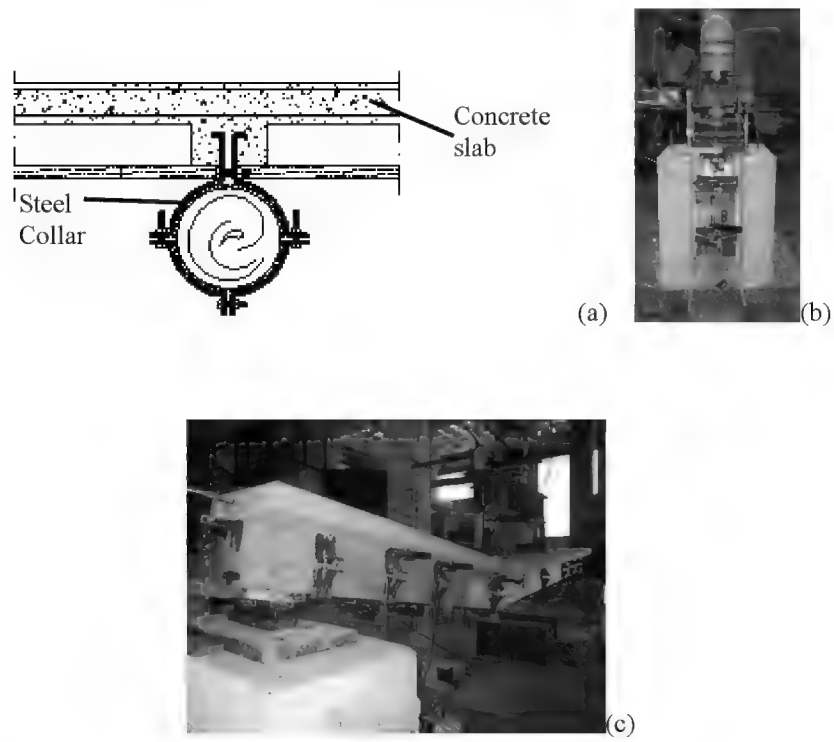


**Figure 12.** The 1:3.5 scale model of the St. Nikola Church.

Also the experimental activity on timber sub-systems has been developed in two main groups of tests. The first group has been related to the tests carried out on timber composite beams and floors, at the University of Naples “Federico II” (Italy) and at the Instituto Superior Técnico of Lisbon (Portugal), both cases being based on an innovative technological solution useful for connecting timber elements and concrete slabs (Fig. 13) (Calado et al., 2008). Such systems have been applied as a consolidation intervention in the Diplomatic Hall of the Royal Palace in Naples (Faggiano et al., 2005) which is shown in Figure 14. The second group of tests has been carried out at the Boğaziçi University of Istanbul and has been related to the study of the behaviour of timber frames equipped with metal shear panels (Fig. 15). The experimental investigation on innovative devices has been aimed at characterizing the performance of systems conceived to increase the seismic protection of historical and monumental buildings. A wide campaign on the cyclic behaviour of pure aluminium shear panels has been carried out at the University of Naples “Federico II” (Italy) and at the University of Chieti-Pescara “G. D’Annunzio” (Italy) (De Matteis et al., 2007, 2008). The experimental tests have been carried out on both full bay and bracing type pure aluminium shear panels (Fig. 16). In particular, four full bay and four bracing type specimens have been considered. For both groups of experiments, the main differences among the tested systems are related to the presence of adequate stiffening ribs on the panels and to the connection (bolted or welded) between the ribs and the panels. The basic innovative devices used for the realization of composite timber-steel-concrete elements have been subjected to extensive experimental investigations (Figs. 17a,) at the University of Naples “Federico II” (Italy) and at the Instituto Superior Técnico of Lisbon (Portugal). A special dissipative beam-to-column node has been conceived at the University of Naples “Federico II” (Italy) and has been subjected to experimental investigations devoted to evaluate the node capability to dissipate the input seismic energy by a torque mechanism in metal elements placed in the nodal area (Fig. 17b). For the connection of marble elements, special steel anchors have been studied at the Technical University of Athens (Greece) by performing pull-out tests on threaded reinforcement bars installed in drilled holes and connected to the marble by means of a suitable concrete material. Moreover, special metallic devices for the connection of marble architraves have been tested at the University of Ljubljana (Slovenia), in order to assess the effectiveness of such innovative system in linking marble blocks to each other. Further experiments on devices are referred to iron connections (University of Liège, Belgium, together with University of Naples-Architecture Faculty, Italy), to magneto-rheological devices at the Second University of Naples (Aversa, Italy), and to DC90 dampers at the University of Ljubljana (Slovenia).

The tests on materials and elements have represented the basis for all aforementioned experimental analyses at different scales. Simple elements and materials have been characterized from the mechanical point of view, so allowing the correct interpretation of the experimental results coming from the large scale tests. Experimental campaigns have been performed, in particular, on elements made of: adobe (Rabat, Morocco), bricks with mortar (Skopje, Macedonia), stone (Rabat, Morocco and Algiers, Algeria), marble and limestone (Ljubljana, Slovenia and Athens, Greece), iron (Liège, Belgium and Naples, Italy), aluminium (Naples, Italy), timber (Istanbul, Turkey and Naples, Italy), concrete (Bucharest, Romania).





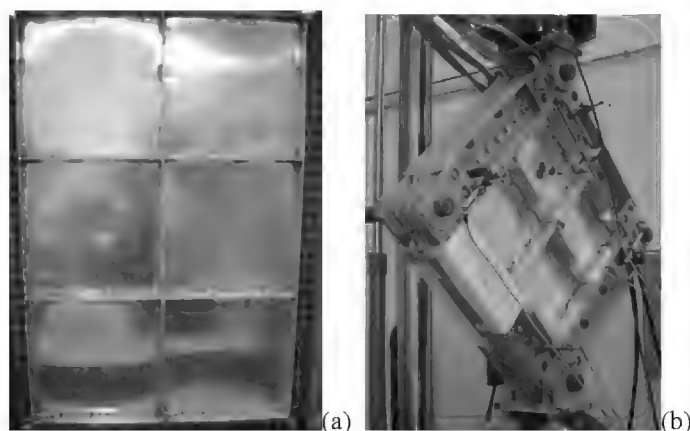
**Figure 13.** Timber-steel-concrete connections: (a) scheme; (b) push-out test; (c) test on composite beam.



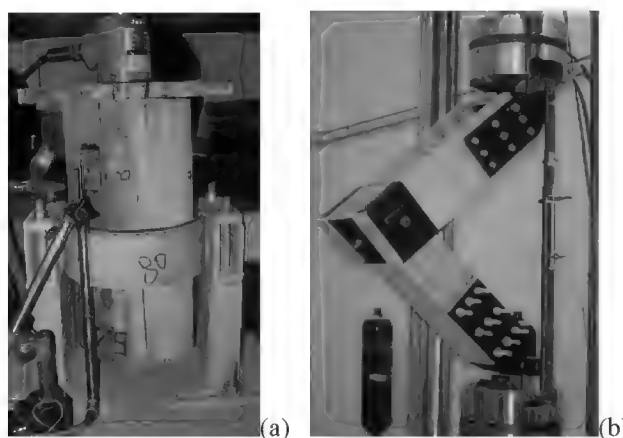
**Figure 14.** Consolidation intervention in the Royal Palace of Naples.



**Figure 15.** Test specimen of metal shear panels for consolidating timber structures.



**Figure 16.** Pure aluminium shear panels: (a) full bay; (b) bracing type.



**Figure 17.** Devices tested in Naples: (a) timber-steel connectors; (b) torque dissipative node for timber frames.

### 3 The Numerical activity

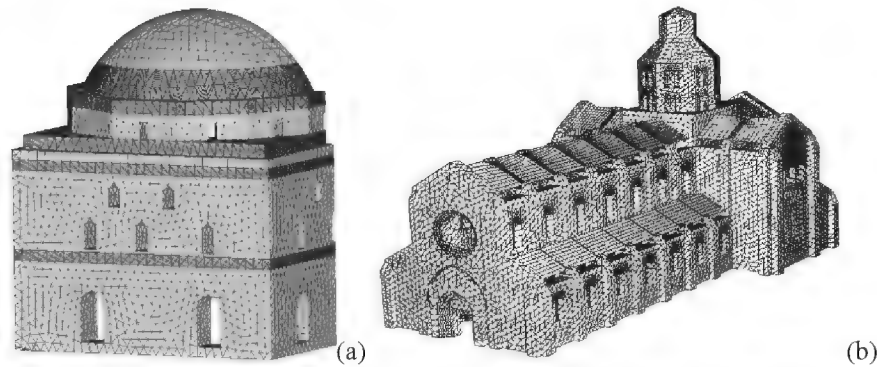
The numerical analyses have represented the counterpart of the experimental tests described in the above section, since most of them have been focused on models of the experimented test specimens. Consequently, also for the numerical analyses, the activity has been developed at five levels, from full scale building to materials and elements. The clear aim of this activity has been the set up of reliable numerical investigation tools, useful for both studying aspects difficult to catch in the experimental tests and providing the basis for the set up of calculation models adequate for historical buildings retrofitted by RMTs.

The whole Bagnoli r.c. building, already described in the section on full scale experimental tests, has been modelled by means of the non-linear finite element program SAP2000 at the University of Naples “Federico II” (D’Aniello et al., 2008). In the numerical model the presence of the innovative BRB retrofitting system has been taken into account, and the numerical results from the static non-linear analysis of the building have well matched the experimental ones. Pre- and post-experimental numerical analyses, devoted to support the development of advanced analytical models, have been performed for the large scale models interested also by the experimental tests. The Mustafa Pasha Mosque has been modelled in cooperation between the University of Naples “Federico II”-Architecture Faculty and the University of Skopje “Sts. Cyril and Methodius” (Landolfo et al., 2007) (Fig. 18a). The Gothic Cathedral of Fossanova has been modelled at the University of Chieti-Pescara “G. d’Annunzio” (Fig. 18b). The model of the St. Nikola Church in V. Psacha has been set up at the University of Skopje “Sts. Cyril and Methodius” (Fig. 19a) and the Greek Temple has been modelled at the National Technical University of Athens (Fig. 19b).

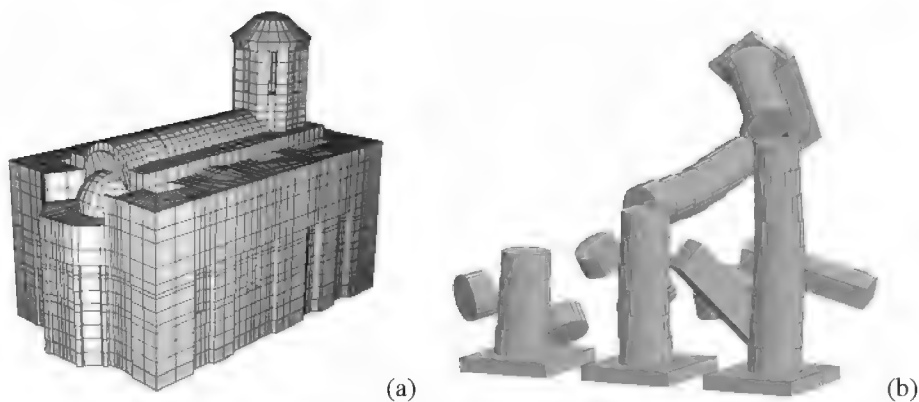
Numerical models aimed at investigating the behaviour of sub-systems endowed with RMTs have been set up. Several retrofitted sub-systems have been considered in the study, namely: masonry walls and metal panels (Fig. 20a, b) (“Politehnica” University of Timisoara – Romania and University of Chieti-Pescara “G. d’Annunzio” – Italy) (Campitiello et al., 2007), masonry walls and FRPs (University of Naples “Federico II” – Italy), timber frames and metal shear panels (Boğaziçi University of Istanbul – Turkey and University of Chieti-Pescara “G. d’Annunzio” – Italy), timber composite floors (Fig. 20c) (University of Naples “Federico II” – Italy and Instituto Superior Técnico of Lisbon – Portugal), iron elements and FRPs (University of Liège – Belgium). In all cases, pre- and post-experimental analyses have been carried out. The pre-experimental analyses have been used for setting up the models and carrying out preliminary studies. The post-experimental analyses have been developed in five phases, namely: the numerical simulation of the original specimens, the modelling of the strengthening devices, the simulation of the strengthened specimens, the comparison with the experimental results and the calibration of numerical procedures for the analysis of the strengthened structural systems.

The activity concerned with the numerical modelling of innovative devices has been subdivided in several steps, following the same approach of the numerical analyses on sub-systems. In fact, after the pre-experimental analyses aimed at setting up adequate numerical models and carrying out preliminary investigations, the post-experimental analyses have been focused on the modelling of the devices, on the comparison of the numerical results with the experimental ones and, as a final step, on the calibration of numerical procedures for the analysis and the design of the devices. The devices modelled numerically are: iron connections (University of Naples “Federico II” – Italy), architrave connections (University of Ljubljana – Slovenia and National Technical University of Athens – Greece), wood-to-concrete connectors (University of Naples “Federico II” – Italy and Instituto Superior Tecnico of Lisbon – Portugal), wooden node dissipative device (University of Naples “Federico II” – Italy) (Fig. 21), pure aluminium shear panels (University of Chieti-Pescara “G. d’Annunzio” – Italy) (Formisano et al., 2006; Brando et al., 2007), magnetorheological devices (Second University of Naples – Italy), and DC90 dampers (University of Ljubljana – Slovenia).

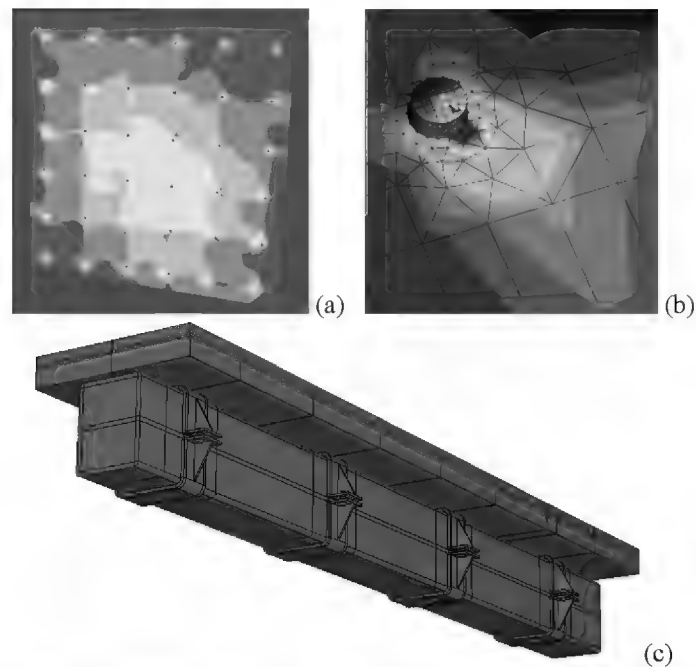
The characterization of the behavioural features of the materials and the elements used for the construction of the models of devices, sub-systems, large scale and full scale systems has represented the basic issue for carrying out the numerical activities. In fact, the calibration of material and element simple numerical models is essential for the set up of more complicated models, from the modelling of the single devices to the numerical investigation of the complex behaviour of the full scale building retrofitted by reversible mixed systems. In this perspective, numerical models of adobe, stone, marble, iron and aluminium have been set up. The models have preliminarily been used for carrying out pre-experimental numerical analyses; then, after the experimental tests, the numerical models have been calibrated and numerical post-experimental analyses have been carried out with the aim of calibrating the numerical constitutive laws to be used in the models at larger scales.



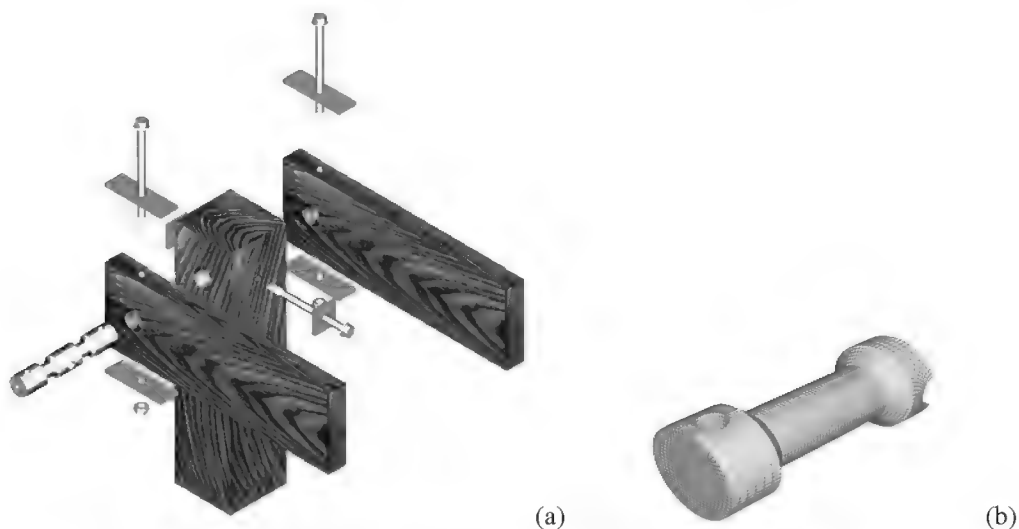
**Figure 18.** FEM models: (a) Mustafa Pasha Mosque; (b) Fossanova Gothic Cathedral.



**Figure 19.** FEM models: (a) St. Nikola Church; (b) Greek temple columns.



**Figure 20.** Numerical models: (a) masonry wall reinforced by metal panels; (b) interface between connector and steel plate; (c) timber composite floor.



**Figure 21.** Dissipative beam-to-column wooden connection: (a) geometry ; (b) FEM model of the nodal metal element.

#### 4 CONCLUSIVE REMARKS

The PROHITECH project has been an important opportunity to develop knowledge and technology in the field of the seismic protection of the Euro-Mediterranean cultural heritage. The innovative character of the technical solutions proposed for seismic retrofitting is mainly based on the concept of reversible mixed technologies. The complexity of the whole research project has been shown, as well as its evident comprehensiveness. An up-to-date state-of-the-art concerning advanced systems of seismic protection for existing constructions has been acquired, so providing a contribution to the specific demand of all European and Mediterranean Countries for a more comprehensive framing of anti-seismic rehabilitation. A valuable contribution to both conscience and knowledge about “new” materials and technologies as a suitable alternative to “traditional” solutions has been provided, since the last ones are proved to be often inadequate to provide a satisfying seismic performance, in particular when applied to historical and monumental constructions. The adoption of materials and systems which are reversible, recyclable, environmentally friendly, and economically sustainable has been supported. Likewise, an extraordinary contribution in terms of both experimental and numerical work on the behaviour of historical constructions consolidated by means of reversible mixed techniques has been given. The experimental results have confirmed the



provisions obtained by the numerical analyses and, above all, the effectiveness of the developed and implemented intervention systems.

A deep dissemination activity of the outputs of studies performed within the PROHITECH project has been made by the partners, who have produced a large number of documents focused on the work carried out. As a whole, the activity, which has involved more than 100 researchers belonging to Euro-Mediterranean Academic Institutions, has led to the production of 16 Project Deliverables and 4 Main Deliverables. The above activity is expected to have important effects on the practice of seismic consolidation and protection of historical buildings, also considering the effort carried out within the project to collect the existing codes and guidelines related to the seismic rehabilitation of buildings by means of innovative techniques, with special emphasis on reversible technologies.

Further information about the PROHITECH research project can be found at the website [www.prohitech.com](http://www.prohitech.com). A comprehensive collection of documents reporting the results of the PROHITECH project (alongside with many contributions on seismic protection of historical constructions coming from worldwide) is also contained in the books entitled “Protection of Historical Buildings - PROHITECH ‘09” (F.M. Mazzolani Editor), Vol. 1 & 2, published by CRC Press as Proceedings of the 1<sup>st</sup> PROHITECH International Conference held in Rome in June 2009 (ISBN 9780415558037).

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## AN APPLICATION OF DIGITAL INFRARED THERMOGRAPHY ON HISTORICAL CULTURAL HERITAGE DAMAGED IN THE L'AQUILA EARTHQUAKE

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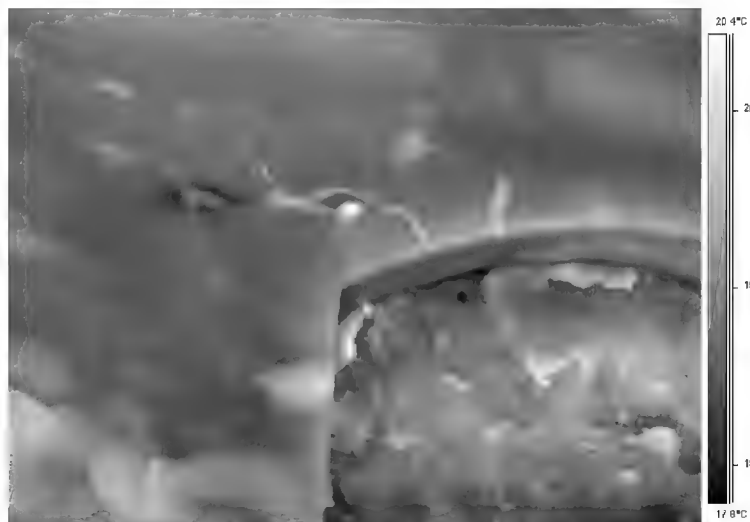
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Digital infrared thermography is gaining an increasing relevance in cultural heritage. Several techniques based on high-resolution infrared thermography have been so far developed to provide an effective and non-destructive test to assess the integrity of historical buildings, masonry and historical masonry, frescoes, and wooden art crafts. The approach most largely used is probably active infrared thermography, in which the structures investigated are cooled or warmed artificially and according specific time-pattern of stimulation. The time-response of the system to the stimuli provides insights about the composition of the structure itself and the presence of discontinuity within it. Usually active infrared thermography methods enable structural investigation of building elements with one-sides access up to a maximum depth of about 10 cm. The thermographic analysis is very common to study the covering surface of the ancient architecture and it allows editing and compiling the conservation state diagnosis. Active thermography is in general very well suited to assess different testing problems in cultural heritage buildings. In this paper, the authors present some innovative applications of digital infrared thermography to cultural heritage.

### **Crack detection in buildings after earthquake.**

The 04/06/2009 earthquake in L'Aquila (Italy) has seriously damaged the architectonical patrimony of the city. The large majority of the historical churches and building has been damaged. The major problem that rescuers have had to face is to bring damaged buildings in security for successive restoration. The authors used digital thermography to monitor and detect the presence of invisible-to-eye crack networks insisting among major cracks. Figure 1 shows a case report of a crack network lying under the outer wall layers, who resulted only partially visible in the optical range.



**Figure 1:** Crack network located between the largest cracks and not visible by eyes.

In this case, the use of multispectral cameras and the appropriate restitution technique permitted to address better the ultrasonography investigation.

### **Moisture detection in frescoes**

Active differential thermography has been used to assess the presence of moisture in a VIII century A.C. frescoes, located under the ground level. In this case, digital thermography allowed at evaluating the effects of the local micro-climate and vapour persistence caused by an unfavourable ventilation. Multispectral thermography was performed twice on the same region, in order to get a complete characterization of the effects of the local micro-climate. In this case, the functional stimulation was provided by the natural temperature variation associated with diurnal light cycle.

Digital telethermography is a promising technique to be applied to cultural heritage. Its relatively low cost, easy portability and capability of quantitative and accurate evaluation of the structures temperature allows for a large use of the method in cultural heritage.

**CULTURAL HERITAGE BETWEEN LANDSCAPE EVOLUTION AND  
MONUMENT RESTORATION. ITALY CASE STUDY: 2009,04,06  
L'AQUILA AND NEIGHBOURING AREA EARTHQUAKE**

(Photo E. Burri and Carsa Edizioni Pescara)

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## **Wiew of city of L'Aquila**





**The Basilica of Collemaggio**



**Front of the Basilica of Collemaggio**



**Interior of the Basilica of Collemaggio**



**The interior of the destroyed Collemaggio Basilica**



**Basilica of Collemaggio: first aid and coverage**



**Government Building**



**The Government Building destroyed by earthquake**



**Government Building: consolidation of the colonnade on the facade**



Church of St. Maria del Suffragio: before and after the earthquake, with its dome collapsed



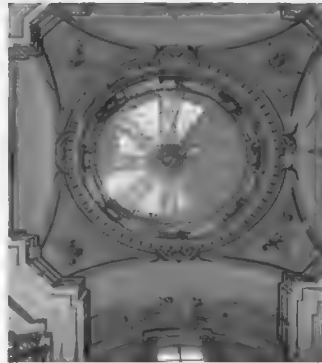
Church of St. Maria del Suffragio

Technology for the construction of a temporary dome made of new materials waiting interior restoration



Church of St. Maria del Suffragio

Technology for the construction of a temporary dome made of new materials waiting interior restoration



Church of St. S. Maria del Suffragio  
the debris of the collapse are collected and conveyed to the work station for the selection of materials



Church of St. S. Maria del Suffragio  
the stones are placed on a slow tape that allows experts to select the materials to use for the restoration with the same stones and with the same characteristics



The cloister of the Palazzo Carli awaiting the start of restoration



The historic center of L'Aquila: the crusher made particularly difficult on early restoration



Church of St. Gregorio in the province of L'Aquila.  
Some monuments may not be restored due to the severity of damage



**S. Maria di Roio before the earthquake**



**S. Maria di Roio:  
the securing of the top of the building and bell tower**



**Church of St. Peter before the earthquake**



**Seismics damage to the Church of St. Peter**



**Church of St. Peter:  
the securing of the facade roofing with ultralight materials**



**Celano: the location of the Superintendence of  
Cultural Heritage of the city of L'Aquila**



**The restoration of the statue of Our Lady of Collemaggio,  
the symbol of religious faith of the city of L'Aquila**



**The medieval tower of St. Stefano di Sessanio: deployment  
of materials to guide next phase of reconstruction**



## SESSION A4 – GIS: ARCHAEOLOGICAL SITES

### INTEGRATED GEOPHYSICAL SURVEY OF THE MEDINET MADI ARCHAEOLOGICAL SITE (FAYOUM, EGYPT)

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#### Abstract

The integrated geophysical survey of the Medinet Madi archaeological site (Fayoum, Egypt) allowed the identification of several targets of potential archaeological interest buried in sandy loam in the depth range between 100-400 cm. The methodological development focused on Multi-Fold (MF) Ground Penetrating Radar (GPR) imaging and subsurface characterization based on integrated velocity and attenuation analysis. 3-D multi-attribute analysis was further performed to detect weak anomalies of difficult interpretation on amplitude volumes. Magnetic gradiometry completed the set of geophysical measurements in a sector of the study area characterized by buried remains of adobe houses. Joint interpretation of geophysical data was exploited to identify low contrast targets, as most of the sector of study was characterized by buried adobe walls with variable content of organic matter (basically palm tree fiber and leaves) in a highly heterogeneous sandy loam. MF-GPR provides a sharp image of the buried structures. Several zones characterized by different radar response can be recognized from slices of the GPR volume and the results are validated by the magnetic anomaly at the location of buried adobe walls. The top of the buried remains is identified with depth uncertainty in the range between  $\pm 10$ cm. Information about geometry and location of targets is integrated by attenuation and velocity of radar waves, which provide direct evidence of varying electromagnetic properties (conductivity, dielectric constant) and allow a detailed characterization of the surveyed volume based on physical characteristics of buried materials. More than 2600 sqm were surveyed with 0.5 m line spacing. The results were validated by archaeological excavation.

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**Keywords:** geophysics, archaeology, GPR, magnetic gradiometry, instantaneous attributes

#### INTRODUCTION

The integration of geophysical methods is a promising strategy in pre-excavation archaeological surveys. Applications of combined techniques can be successful in the preliminary exploration of pre-historical sites (see e.g. Forte and Pipan, 2008) and of archaeological sites of later periods (see e.g. Pipan et al., 2005). The contrast in physical properties of the materials and the sensitivity of the different methods play a key role in the application of geophysical methods to archaeological surveys and determine the probability of success. Adobe buried remains are a particularly difficult target in archaeo-geophysical prospecting, due to the usually low contrast of physical properties deriving from the similar composition of materials of archaeological interest and surrounding sediments. Such conditions are expected and partly verified by previous archaeological excavations in the area of study of the present work, the Medinet Madi site (Egypt). We therefore combined GPR and magnetic gradiometry to assess the archaeological potential of a 2600 sqm area scheduled for successive excavations. GPR is extensively applied to study archaeological sites (see e.g. Vaughan, 1986; Goodman et al., 1995; Malagodi et al., 1996; Pipan et al., 1996a,b;). The indications of the archaeological team encouraged the integrated application of GPR with magnetic gradiometry, based on the following reasons:

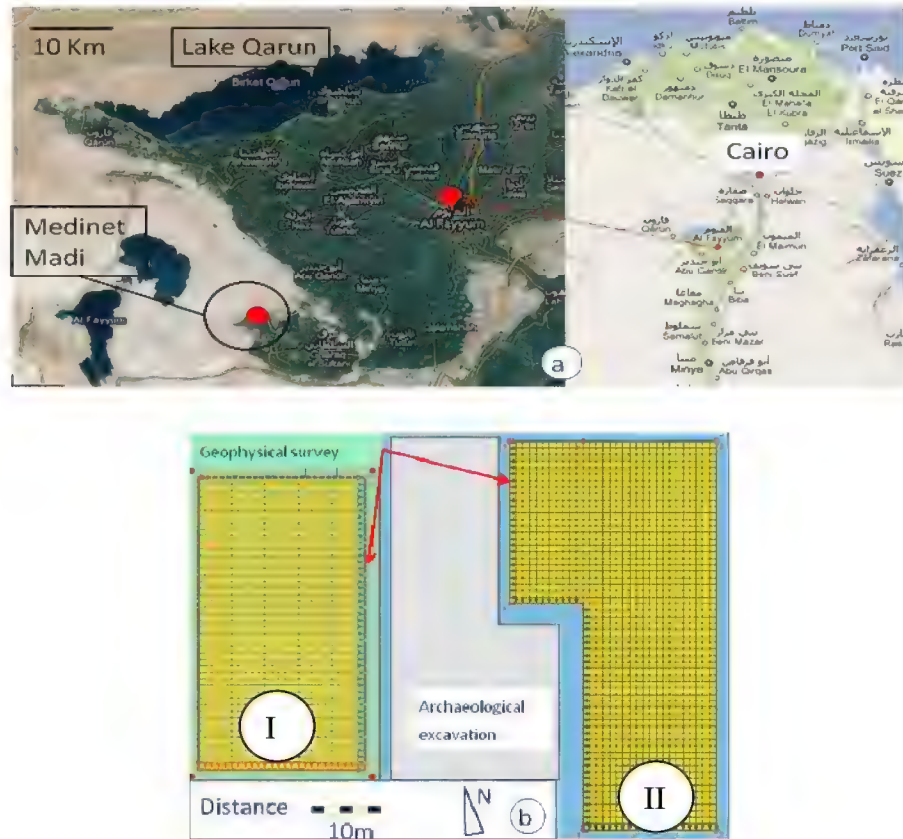
- Previous archaeological excavations discovered a Ptolemaic temple and nearby adobe buildings to the NE of the area of study. Part of the walls of such buildings extends towards the area of study. Tools and objects found in large numbers close to the walls excavated to date may be the source of perceptible magnetic anomalies;
- The schedule of the archaeological, geophysical and engineering study required to optimize the survey design by focusing the high resolution MF GPR techniques on the sectors of major interest identified from the integrated interpretation of Single-Fold (SF) GPR exploratory profiles and magnetic anomaly maps.

The area of study is characterized by a shallow layer of highly heterogeneous sandy loam with variable quantities of palm tree fibers and leaves that were extensively used for shelters and roofs. Based on tests performed close to the archaeological trenches, the top of adobe produces a detectable GPR response and this technique is therefore suited for extensive explorations. The use of magnetic methods to study archaeological sites and targets of similar



characteristics is well documented in literature (see e.g. Becker and Fassbinder, 2001). MF GPR techniques were exploited to provide location and depth of the targets of potential interest, which were proposed for excavation trenches.

The results of the geophysical study show clear GPR anomalies at depths not exceeding 300 cm, spatially correlated across the grid and locally well associated with the magnetic profiles, which were successively verified by archaeological excavations.



**Fig.1** – Location maps of a) the Medinet Madi area b) the area of study (red dot in the black circle of Medinet Madi **Fig.1a**); sectors I and II were excavated after the geophysical survey.

## METHODS

We used surface MF GPR to survey an area of 2600 sqm located in the Medinet Madi archaeological site (Fig. 1a,b). The GPR dataset was integrated by magnetic gradiometry performed at 1 meter vertical separation between sensors and with lower sensor located about 0.20 meter above ground level.

The radar was a RAMAC GPR equipped with 100 MHz unshielded and 250-500 MHz shielded antennas. Unshielded and shielded antennas were used for Single-Fold and Multi-Fold data acquisition. The magnetic gradiometer was a cesium Scintrex SM4-G magnetometer.

A SF survey of the whole study area was performed using 250 MHz shielded antennas along parallel profiles spaced out 1 metre apart. Multiple common offset profiles were then completed to obtain MF sections with average 1200% fold, using shielded antennas characterized by central frequency between 250 and 500 MHz.

The processing sequence focussed in particular on:

- Background removal by means of Hough Transform based algorithms
- Velocity analysis (LMF)
- Amplitude analysis (LMF)
- Azimuthal Amplitude Analysis (AMF)
- Azimuthal Velocity Analysis (AMF)
- Pre-stack and post-stack migration
- Identification of weak reflectors in noisy background (deep remains-soil contacts) based on the analysis of Instantaneous Parameters calculated by means of Wavelet Transform (WT).

We further performed a 3-D analysis based on four classes of attributes, namely: instantaneous, amplitude, frequency and coherency related (see e.g. Chopra and Marfurt, 2007).

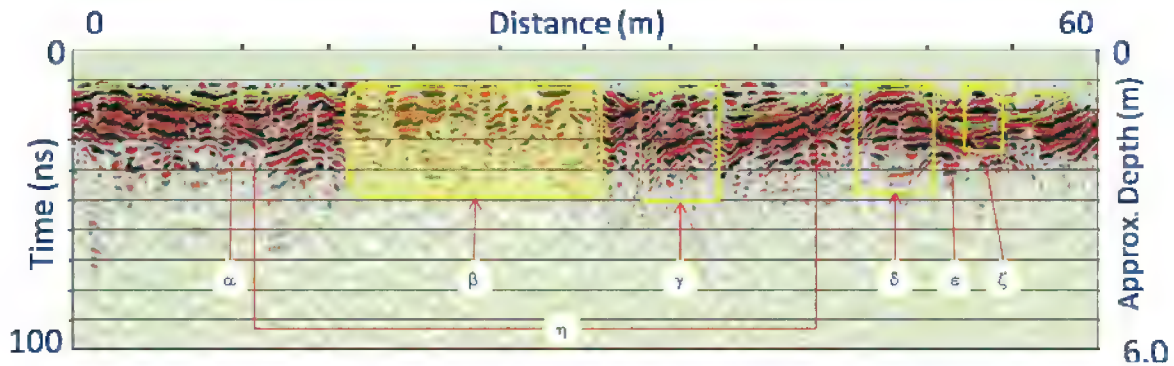
The magnetic survey was performed at a 10 samples/second measuring rate. We analysed gradient and data from each sensor, the latter after reduction to mean value calculated with three different methods: 25 m means, 25 sqm

(5x5m) means or after median equalization between profiles and cubic polynomial regression and subtraction (see e.g. Tabbagh, 2003).

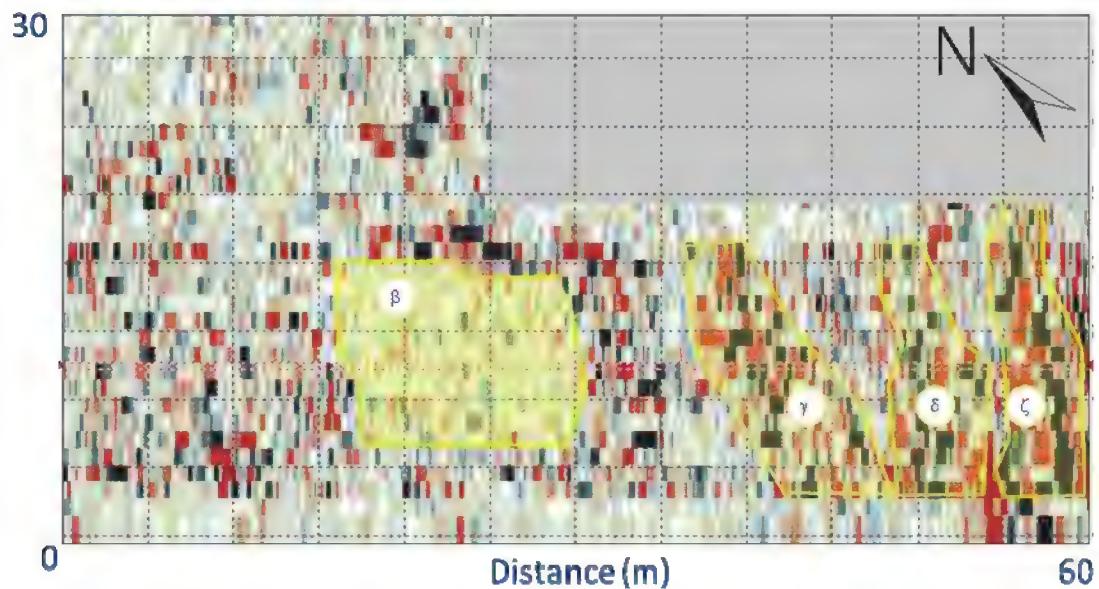
Archaeological excavations were available in the area of study and were utilized to calibrate and validate part of the results.

## RESULTS

Fig.2 and Fig.3 show examples of vertical and horizontal slices of the processed and migrated 3-D MF GPR data volume. The interpreted targets in Fig.2 are reported in Greek letters: ( $\alpha, \eta$ ) are the shallow and deeper GPR reflectors in the area, the latter ( $\eta$ ) associated with the contact between sandy loam and adobe remains; ( $\beta$ ) is a sector with higher attenuation, associated with the inner part of an approximately rectangular structure (see Fig.3); ( $\gamma, \delta, \zeta$ ) are prominent features characterized by high amplitude response associated with larger contrast between sandy loam and targets (stones flanking the *dromos* of the Middle Kingdom Temple); ( $\epsilon$ ) is a shallower GPR reflector, identified locally and possibly associated with recent eolic deposition above consolidated layers of archaeological interest. Fig.3 provides a plan view of sector II (see location map, Fig.1b) through a non-interpolated time-slice at 16 ns. Location of targets ( $\beta, \gamma, \delta, \zeta$ ) is obtained from the integrated interpretation of amplitude, frequency and coherency attributes. The boundaries of target ( $\beta$ ) are set by a sharp discontinuity in the above set of parameters. Based on nearby excavations, the GPR response may be associated with an adobe building with collapsed roof and chaotic filling of the inner part. Similar results are obtained in sector I and are synthesized by a plan view obtained from the processed magnetic data (Fig.4). The geometric coherence of the targets of archaeological interest is highlighted by the darker blue rendering. The strong dipolar anomaly close to the southern corner of the map (letter F on Fig. 4) is due to a small and recent furnace.

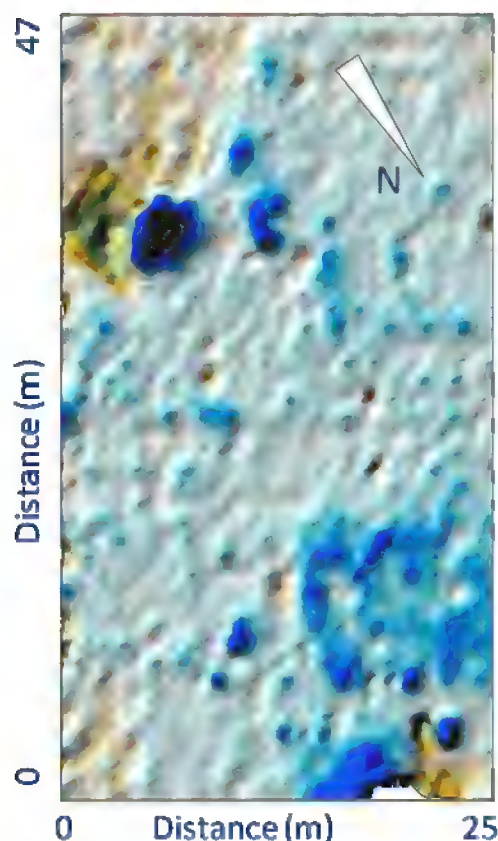


**Fig.2** – Example of processed 250 MHz GPR section, sector II (see text for details)



**Fig.3** – Example of 250 MHz GPR time-slice across the processed and migrated 3-D data volume, sector II (see text for details)





**Fig.4** – Magnetic anomaly map, sector I, dynamics -30.00/+30.00 nT in colour scale (white to dark blue), reduction on 25 sqm means

## CONCLUSIONS

The analysis of the geophysical dataset obtained at the Medinet Madi archaeological site gives evidences of the excellent performances of integrated geophysical techniques for the identification and mapping of low-contrast buried cultural heritage. MF GPR and magnetic gradiometry provide an effective solution to detect targets, which exhibit small differences in physical properties with reference to the surrounding sediments due to their high sensitivity and resolution. A large fraction of the cultural heritage buried in the area of study is made of adobe and buried in sandy loam, i.e. rather hostile conditions in terms of contrast of electromagnetic properties. Nevertheless, both the GPR and the magnetic datasets provide high quality results that highlight the location of the targets of interest. A possible explanation is the different clay and organic matter fraction in soil and adobe. Adobe bricks are normally richer in both components, a characteristic that affects both dielectric constant and magnetic permeability. The dynamic of the magnetic response varies in the range between -30.00/+30.00 nT but seems limited to a more restricted interval (i.e.  $\pm 5$  nT) for the targets of interest. GPR vertical and lateral resolution is decimetric and adequate for the objective of the survey. Depth penetration is in the range between 150 and 500cm, on the average adequate for the objectives of the survey. The variations depend on local soil conditions and particularly on lenses of inorganic and organic debris, which are imaged by GPR and cut by the archaeological excavation. Depth calibration was performed by means of MF data analysis and validation at the soil face exposed by the archaeological excavation. Deep buried structures affect the deformation of shallow layers and allow therefore the extension of the GPR depth range in the interpretation phase. The integrated data analysis provides a good correlation between magnetic anomalies and GPR reflections/diffractionss, which indicates that most targets in the area of study are characterized by joint variations of EM properties (i.e. permittivity/conductivity and magnetic permeability). GPR is adequate to image the shallow 3 to 5 meters. Information concerning deeper targets can be extrapolated from the detailed reconstruction of the deformation of the shallow layers. The profiles obtained by means of MF methods actually exhibit extended depth range due to substantial signal-to-noise ratio enhancement in the deepest part of the record.

Several targets of potential archaeological interest were identified from the integrated GPR and magnetic data analysis and interpretation. Two major GPR reflectors ( $\alpha$ ,  $\eta$  in Fig.2) and an additional ( $\epsilon$ ) shallower one were interpreted and correlated in the area. Four prominent targets ( $\beta$ ,  $\gamma$ ,  $\delta$ ,  $\zeta$ ) are identified in sector II, and additional features characterized by weaker response in sector I. The location and azimuth of buried targets identified by the geophysical survey is compatible with the previous results of archaeological work and was validated by successive excavation tests.

## ACKNOWLEDGMENTS

We gratefully acknowledge the support of the following companies and institutions: Halliburton through Landmark academic grant; Italian Ministry of Foreign Affairs and Italian National Research Council (CNR) under research grant 99.03773.PF36; EU for funding through Tempus ATECH project and FP7 MICCS project. We thank Edda Bresciani and Rosario Pintaudi, scientific responsible of the archaeological project, for support and helpful comments. We gratefully acknowledge the assistance of the Direction and Staff of the Italian Institute of Culture at Cairo and thank OpendTect for providing the open source interpretation software used for 3-D data analysis.

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## ON THE USE OF VHR SATELLITE DATA IN ARCHAEOLOGY AND PALEOENVIRONMENTAL STUDIES

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The importance of applying space technology to archaeological research has been paid great attention worldwide, mainly because nowadays the spatial capability of Very High Resolution (VHR) satellite data is comparable with aerial photogrammetric images. For the last century, aerial photos have been the most common remote sensing data source used in the field of archaeological investigations. The low spatial resolution of early satellite sensors, such as Landsat Thematic Mapper (30 m) or Spot (10 m), did not provide sufficient precision for the identification and inspection of archaeological sites. This restricted the application of satellite data to human ecology, landscape archaeology (Sheets and Sever, 1988; Clark et al. 1998, Sever, 1998) and paleo-geographic studies (Parry, 1992, Drake, 1997, White and Asmar 1999). In the last decade, the increasing development of ground, aerial and space remote sensing techniques and the tremendous advancement of Information and Communication Technologies (ICT) have focused a great interest on the use of satellite imagery in archaeology and paleoenvironmental studies. In particular, the improved spatial and spectral capability of active and passive sensors has opened a new challenging perspective for the use of remote sensing technologies not only for the investigation, but also for the management and valorisation as well as for the monitoring and preservation of cultural resources. The availability of Very High resolution (VHR) of multispectral satellite images, such as (i) IKONOS (1999) with panchromatic at 1 m, and multispectral at 4m, (ii) QuickBird (2001) with panchromatic at 0.6m and multispectral at 2.4, and (iii) Worldview (launched in the late 2007) panchromatic at 0.5m, offers improved capability in locating potential buried archaeological sites. Moreover, the launch of WorldView-2 (anticipated October 2009) will provide imagery with a spatial resolution of 46 cm (panchromatic) and 1.84 m (multispectral -Blue, Green, Red & Near-Infrared). Beside the four standard bands the WorldView-2 imagery will also contain 4 additional colours (red edge, coastal, yellow and near-IR2).

The application satellite remote sensing techniques has significant potentiality for archaeological research and paleo-environmental studies in different applications (i) detection, identification and mapping of new archaeological features (such as sites, road segments, and field patterns), (ii) reconstruction of ancient landscape, (iii) documentation, management and valorization of cultural heritage, (iv) monitoring of natural risks (such as landslide, fire, earthquake, flood) for cultural heritage. Examples of investigation focused on points (i) to (iv) will be presented in discussed in detail for several archaeological areas in South America (Tiwanaku -Bolivia, Nasca Perú;), Italy and Turkey.

# ON THE INTEGRATION OF AIRBORNE FULL-WAVEFORM LASER SCANNING AND SATELLITE IMAGES TO DETECT AND MAP ARCHAEOLOGICAL REMAINS

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## Abstract

This paper deals with the use of aerial photos, satellite imagery, and Airborne Laser Scanning (ALS) for the detection of archaeological features linked to man-made transformation of the landscape. The research postulates a combined use of historical documentation and field survey with non invasive remote sensing technologies. The investigation was carried out for two lost medieval villages Monte Irsi and Monte Serico both of them located in the Basilicata Region (Southern Italy). Results from aerial photos and satellite data enabled us to detect the remains of the lost medieval villages, whereas the detailed Digital Terrain Model (DTM) from the ALS data provided a detailed characterization and map the urban fabrics. Our investigations pointed out that the ALS is a valuable data source to detect and map micro-topographic reliefs linked both to cultural and geomorphological features also covered by slow and dense vegetation.

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**Keywords:** Landscape archaeology, Lidar, deserted medieval villages, satellite images, aerial photos.

## 1. Introduction

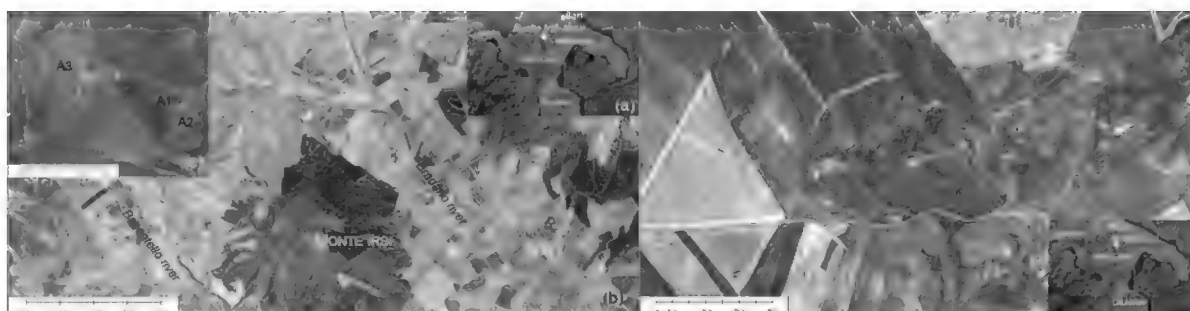
The combined use of satellite images (TM, IKONOS, QuickBird) with high resolution Digital Elevation Model (DEM) such as those from radar or LiDAR (Rowlands and Sarris, 2007) can improve capacity to record the subtle morphological remains linked to past human activity. Different sensors can be used to detect different kinds of archaeological marks, such as, crop, soil and shadow marks, linked to variations in vegetation (in growth and/or color), soil moisture content, and micro-topographic relief, respectively. In particular, soil and crops marks, can be detected using aerial photos and/or optical satellite images. Micro-topographic relief can be better detected by using Airborne Laser Scanning (ALS), see, for examples, Devereux et al. 2005, Crutchley S 2008, Corns and Shaw, 2008. Buried structures without surviving in (micro-) relief cannot be detected by ALS, but can be successfully emphasized by using aerial and satellite images. On the other side, ALS offers the unique capability to penetrate vegetation canopies and identify earthwork features even under dense vegetation cover (Doneus et al. 2008). This paper is focused on a combined use of historical documentation and field survey with non invasive remote sensing technologies for the detection of archaeological features linked to man-made transformation of the territory from a site level up to a landscape perspective. Aerial photos, satellite imagery, and Airborne Laser Scanning (ALS) have been used to reconstruct the urban topography and cultural landscape of the archaeological area of Monte Irsi (Southern Italy).

## 2 Study areas

The investigation was carried out for two lost medieval villages Monte Irsi and Monte Serico (see Figure 1 left and right, respectively) both of them located in the Basilicata Region (Southern Italy).

Monteserico is located on a hill at around 590 m a.s.l. which faces over a wide territory characterized by hills and plains crossed by the Basentello river. The area is characterized by a rich presence of archaeological remains due to its strategic position, and fertile land. Traces of human presence belonging to different historical period, from the Iron to Middle Ages (see Lasaponara et al. 2010 and references therein) have been only partially identified up to now. Historical sources state that around the 11th century, a castle was built on the hill. The Monteserico village was founded in the 13th century and gradually abandoned, for reasons still unknown, between the end of the 14<sup>th</sup> and the first half of 15<sup>th</sup> century.

Monte Irsi, located close to the border between Basilicata and Apulia, near the confluence of the Bradano and Basentello rivers, characterized by the presence of vegetation made up of dense herbaceous plants. The strategic location of Monte Irsi favoured a long and intensive human activity from Paleolithic to Middle Ages, as testified by archaeological remains (see Masini et al. 2010 and references therein). As regards to the Middle Ages, documentary sources state the existence of a village (Yrsum) and a monastery. The village achieved its maximum expansion in the 13th century. At that time there were around 900 inhabitants.



**Figure 1** Study area

### **3 Data and processing**

This research postulates a combined use of historical documentation and field survey with non invasive remote sensing technologies to reconstruct the urban topography and cultural landscape. This section presents data used and processing adopted for both spatial characterization of the urban fabric and detection of traces of past landscape.

#### **3.1 Optical Data and processing**

Aerial Photos and satellite imagery were mainly used to identify traces of past landscape. Aerial photos were taken at the same time as LiDAR data acquisition using a digital camera Digicam H39 with 39 Mpixel.

Satellite data were acquired from QuickBird. It offers panchromatic and multispectral imagery; panchromatic has a spatial resolutions of 62 cm, multispectral of 2.48 m, depending upon the off-nadir viewing angle. The panchromatic sensor has a bandwidth of 450 e 900 nm. The multispectral sensor acquires data in four spectral bands from blue to near infrared (NIR). Both panchromatic and multispectral sensors offer 11 b (2048 grey levels) resolution. The Satellite QuickBird Images were acquired in July 2004 and October 2006. Results from previous studies based on aerial photos and 2004 satellite imagery processed using data fusion and edge detection algorithms (as in Lasaponara and Masini 2005) allowed us to identify the location of medieval villages (Lasaponara and Masini 2005, Lasaponara and Masini 2006).

Aerial and satellite images were ortho-rectified using the Global Mapper.

#### **3.2 LiDAR data and processing**

Airborne Laser Scanning (ALS) is an active remote sensing technique which provides direct range measurements between laser scanner and the Earth's surface. Such distance measurements are mapped into 3D point clouds. The LiDAR survey was carried out by GEOCART s.r.l. on the 18<sup>th</sup> November 2008 using a full-waveform scanner, RIEGL LMS-Q560 on board a helicopter to obtain a higher spatial resolution.

The flight was operated with a share around 400 m, a speed 25.7 m/s, and an opening angle at 60°. The scanner acquired data in the direction South-North and East-West, with a divergence of the radius 0.5 mrad, and a pulse repetition rate at 180.000 Hz. The average point density value of the dataset is about 30 points/m<sup>2</sup>. The accuracy is 25 cm in xy and 10 cm in z (altitude).

The workflow for processing airborne laser data (LiDAR) and airborne images may be divided into five major steps: (i) initial setup and data calibration, (ii) classifying points, (iii) processing images, (iv) validating positioning, and (v) creating delivery products.

The initial setup involves importing all the necessary raw data into the processing software, applying coordinate transformations and calibration, which is based on the comparison of the laser data produced by different flight passes which overlap each other.

Later both Digital Surface Model (DSMs) and Digital Terrain Model (DTMs) are obtained. For archaeological investigation, a high quality digital terrain model (DTM) has to be derived from the ALS data. This demands a detailed and reliable separation of on-terrain and off-terrain points while maintaining a high point density. The separation of terrain and off-terrain points is generally called classification, and can be obtained (see Lasaponara and Masini, 2009) using the diverse laser measurements and information, such as: (i) height; (ii) intensity; (iii) echo width. Herein, we will focus on the elaboration performed using both height, obtained from the 3D point clouds, and orthophoto acquired at the same time as ALS survey.

Due to its efficient data sampling capabilities, FW-LIDAR is capable of detecting microtopographic relief with an altimetric resolution of <0.1m. To achieve this level of resolution, It is necessary to process the ALS point cloud using appropriate numerical filters. For this case study, to achieve this level of resolution the Gaussian Pulse Estimation (Shie Qian and Dapang Chen 1996) algorithm implemented in the commercial software Terra Scan (Terrasolid, [www.terrasolid.fi](http://www.terrasolid.fi)).

TerraScan classification is based on a parametric approach and develops according to an orderly sequence of stages decided by an operator. In this case study, the classification of laser data was performed using a strategy based on a set of "filtrations of the filtrate". Appropriate criteria for the classification and filtering were set to gradually refine the intermediate results (see Lasaponara et al 2010) reliable discrimination of terrain and off terrain objects.

#### 4 Results

Optical imagery (aerial photos and satellite) have been used to detect the archaeological features, mainly visible from soil and crop marks, linked to the buried medieval village. For both the investigated areas, the archaeological remains were further investigated by using aerial LiDAR survey to capture micro-topographic relief variations unseen from the optical data set. The high resolution Digital Terrain Model (DTM) obtained from LiDAR allowed the detailed identification of small relief produced by surface and shallow archaeological remains and the detailed reconstruction of the urban fabric. Figure 2 and Figure 3 show results obtained for Monte Irsi and Monte Serico, respectively.

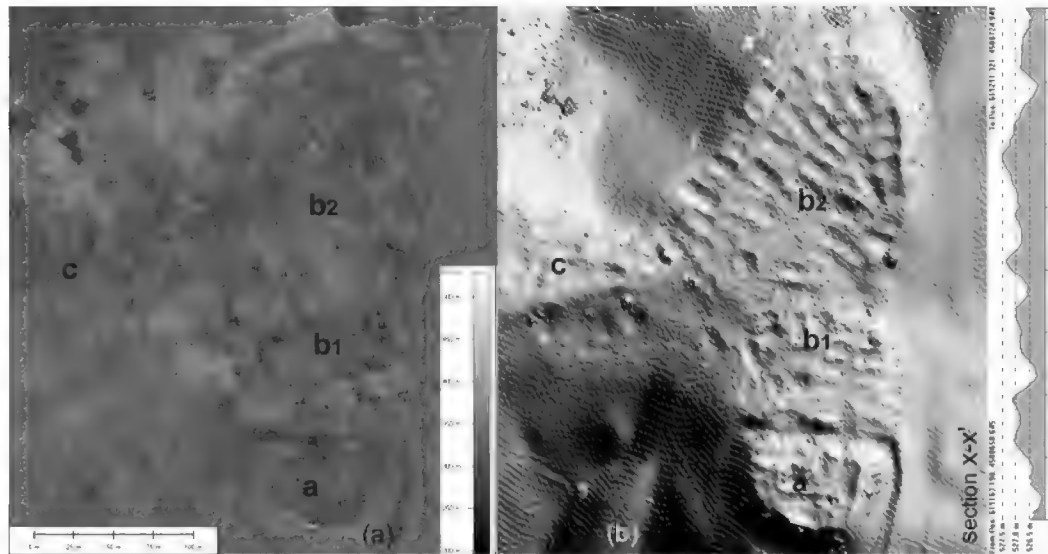


Figure 2 Monte Irsi :orthophotos (left) and LiDAR DTM (right)

The DTM together with the altitude profiles (see as an example figure 2 right) allows us the reconstruction of the urban fabric of Monte Irsi and Monte Serico.

For Monte Irsi, the morphological interpretation of the micro-relief pattern puts in evidence four different sectors (“a”, “b1”, “b2” and “c”, shown in fig. 2) and a landslide not clear visible from aerial photos and VHS satellite imagery. The four sectors could be related to different historical phases of the village, whereas the landslide was a probable cause of the abandonment of the village.

For Monte Serico, it is possible to discriminate a radiocentric pattern of archaeological features in the southern sector which develops according to the altitude level. A field survey performed on this area revealed the presence of a rich quantity of medieval pottery, in particular dating back to the 13-14<sup>th</sup> century (Ciriello et al. 2007).

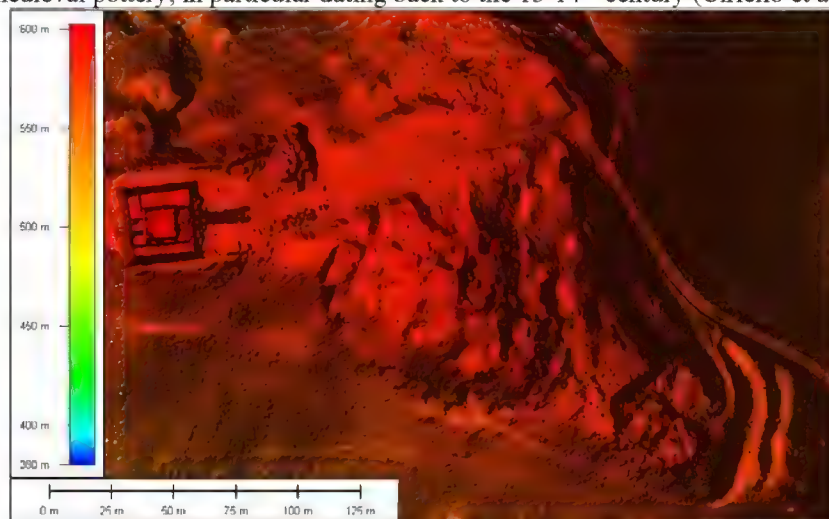


Figure 3 DTM for Monte Serico

#### 5 Conclusion

This paper deals with the use of aerial photos, satellite imagery, and Airborne Laser Scanning (ALS) for the detection of archaeological features linked to man-made transformation of the landscape. The investigation was



carried out for two lost medieval villages Monte Irsi and Monte Serico (see Figure 1 left and right , respectively) both of them located in the Basilicata Region (Southern Italy).

The research Results from our investigations pointed out that the integrated use of non invasive remote sensing technologies, besides its important scientific implications, can provide a significant contribution to the detection and knowledge of cultural heritage, from single sites up to a landscape level.

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## GEOSPATIAL ANALYSIS THROUGH A DATA MINING REPOSITORY SCREENING OF TUFF QUARRIES USED IN ANTIQUITY: LAZIO REGION CASE STUDY

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In ancient times the choice of stone materials and constructing systems has always influenced the art of building. The historical quarries and the activities associated with them were an important form of human economic activities, providing the raw material for all types of construction both cheaper than the big monumental achievements. Initially the motivation of this research was the study of tuff quarries exploited in Roman antiquity, then the study was mainly addressed to a particular category of stone materials mentioned by the Classics (Vitruvius et al.) and generically defined tuffs and identified from the same authors with adjectives derived from their color or place of origin (lapis ruber, lapis gabinus, lapis fidenates, lapis pallens, etc.).

The quarries and their products have always represented a meeting point and a multidisciplinary exchanges place. If this fact was a positive between specialists from different backgrounds at the same time has produced a proliferation of heterogeneous scientific terms whose intelligibility has caused and still causes today, despite various efforts and some qualified contributions, identification problems between different lithotypes and their places of supply. Add to this the difficulty of the mismatch of concepts between different languages. In our case study the analysis examined the quarries and their "tuff" products relating to sedimentary pyroclastic rocks. For this purpose we make a proposal of correlations between the different terms, even after a recent geological classification.

From the foregoing it is clear that issues relating to stone resources and all that follows are a privileged place of study and, as such, place of production of large amounts of heterogeneous scientific data.

The conducted study has tested the use of a spatial data mining repository to analyze a huge set of heterogeneous form and content data. In particular they have been stored: geospatial data (remote sensing, aerial photos, thematic maps, topographic maps, digital elevation models, synthetic aperture radar); analytical data (physical and chemical, mineralogical and petrographic, geochemical, sedimentological, paleontological studies); archaeological data and dimensional surveys on materials and structures; historical and archival-bibliographical data.

The goal of storage was, as in the common processing of data mining, to extract through automatic or semi-automatic methods, based on the application of specific algorithms, patterns, models and relations. Synthetically, knowledge in terms of meaningful information that can be used immediately.

The survey conducted with the techniques of classification, clustering, sequential patterns, statistical learning, has allowed us to detect causal relations previously unknown.

Besides, the acquisition of significant data has allowed us the experimentation of useful models for the application also in diverse fields: particularly, the association of various layers of information has allowed to identify modern extractive areas and sites at the environmental risk. This application with the appropriate insertion of the time variable had therefore the opportunity to verify the phenomena of abandonment, abusive exploitation and damaging of the same historical quarries.

# SITES OF TOURIST AND ARCHAEOLOGICAL INTEREST AND THE SUSTAINABILITY OF HUMAN PRESSURE IN THE MEDITERRANEAN BASIN. AN INTERACTIVE MODEL OF GEOGRAPHICAL INFORMATION SYSTEM

TULLIO D'APONTE

*National Co-Ordinator of the FIRB Project "Mediterranean Archeological Tourism"*

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## Summary

Tourism, in its modern forms involving mass flows, is a major responsible factor in the worsening of large geographic areas ecosystems, affected by a progressive extension of both offer and demand.

In such a context, where the entire tourism sector appears to be an industry of tremendous importance and is emerging as one of the major industries of the twenty-first century, *cultural tourism* is becoming increasingly popular and is recording good growth performance.

Different factors may explain the growth of cultural tourism. First, since the seventies of the last century there has been a process of dissemination and democratization of culture that has affected the widening scope of the concept of culture itself.

The appearance on the market of low-cost airline companies, the development of a larger and more diversified tourism model, the evolution of some demographic factors such as the aging of population, have all played an equally undeniable role in this process.

This may mean participation in cultural events, visits to museums or even interrelationships with the local population. Cultural tourism should not be regarded as a well-defined niche within the very wide range of tourist activities, but includes all activities carried out by someone who is in a different place than usual.

The cultural heritage of a city, identity of the places and history of an area, has taken in recent years, a strategic value, giving rise to new forms of competition between local systems, based on an innovative variation of sustainable development, in which the whole is understood as a cultural system of processes laid down in time.

With this in mind, the planning and development of local cultural heritage are no longer identified as simple qualitative development of an area, but represent a new opportunity for the protection and sustainable development of the cultural fabric of a place.

Culture, therefore, no longer seems capable of a distinct and alien vision if compared to the more general logic that govern the phenomena of local development, but is, itself, an active factor for the socio-economic growth of an area. It's a decade now since the discussion about the contribution GIS can give to geographical analysis, has started. At the same time it's equally true that only in recent years the conditions for a widespread – even more sensitive – use of these scientific tools have been realized. And this is just the point: GIS are very advanced intelligence tools and, as such, they have to be used professionally and in ways that maximize the support that they can draw in geographical analysis.

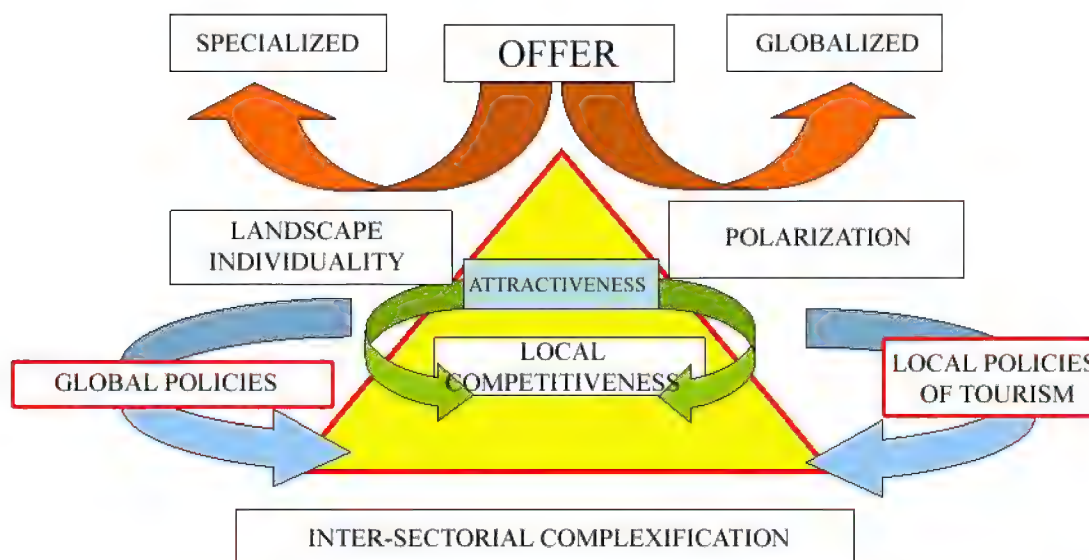
Tourism is by definition one of the areas of research that appear to be potential users of these new technologies: every time data are analysed, their spatial reference, and the part of the territory to which they refer are always included. The project started with the aim of providing a database that allows the storage, management, display of tourism resources. For reasons related to the widespread presence of pre-existing archaeological sites of extraordinary importance and, therefore, the presence of an undisputed high attraction for cultural tourism, the experiment was directed to sites in the Mediterranean Areas. A GIS application that adds to the traditional relational database, the "semantics of where", which facilitate the transition from mere "information", linked to the single resource, to "knowledge" of the area and its social dynamics.

For the development of the client component of this GIS ESRI technology was used: ArcGIS 9.3 suite, still a de facto market standard. As for the central repository of data, however, the platform on which the application is developed has been a Microsoft Access database with both geographic data (administrative boundaries, road graph, etc..) and the traditional alphanumeric ones. This peculiarity has entailed the adoption of one of the developments that have most changed the landscape GIS in recent years: the "geodatabase", ie, the extension of the model to the traditional RDBMS storing geographic data, whether in raster or vector (orthophotos, graphs, grids, etc..) format.

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## 1. *Tourism as a mass phenomenon with high complexity of motivation.*

In the last decades, there were deep transformations in the public and in the approach to the tourist phenomenon: these transformations implied a link between the use of tourism and the idea of choosing an easily recognizable "brand", a brand which identifies the geographic characteristics of a country and supports the process of tourist communication and offer. This simple and drastic principle is not able to define an unambiguous and monolithic image of a country, which cannot be blocked in a natural, cultural, environmental, folkloristic and food unit. In fact, the representation of the local tourist process is more complex: the appeal of a country is based not only on its physical, material and natural characteristics, but also on its social and environmental identity.



**Figure n.1** – Representation of the interaction between different form of tourist offer and sustainability of territorial polarization

Finally, territorial marketing should be based not only on the physical and tangible elements, but also on the invisible emotions which a country creates in its tourists.

## 2. *The cultural appeal as the force of Mediterranean tourism.*

The analysis of tourism in the Mediterranean area should obviously consider the appeal represented by its cultural, monumental and archeological heritage. In fact, it is clear that cultural tourism is one of the first forms of tourism: writers, intellectuals, geographers, keen on classical history and civilization, have always traveled around and about to develop their personal experience and background. We pass from the idea of Roman tourism, linked to the refined image of the “Grand Tour”, to the concrete model of modern mass tourism; initially, this mass tourism was considered as the best way to escape from the daily reality of work, while nowadays it is a strategy to explore and know different places. In this complex contest, it is obvious that the model of cultural tourism cannot be imagined as a simple concentration of tourist-flow towards the most important capitals of art: the tourist offer should cope with a multiform audience, which has different expectations of a holiday (amusement, fun, emotions for new experiences, etc...). The conceptual borders of cultural tourism are really fleeting, exactly as the very concept of culture. If we accept a general definition, cultural heritage will be made up of material and immaterial goods, which, thanks to their historical, cultural and artistic value, testify to usage, customs and spiritual roots of a civil community. It is widely considered that cultural resources are a cause of territorial wealth, implying not only growth of economy and employment, but also a development of local identity. In this perspective, it is really important to consider the connection between tourism as a source of knowledge (tourism as a reason and an effect of cultural process) and tourism as a possibility to produce income for the population of a country (tourism and economy). In other terms, cultural tourism determines not only a spiritual enrichment, because it implies a social dialogue with a different cultural model, but also an economic redistribution and growth in the country involved in this process. The “indistinct tourism”, in which the local community suffers from the violent passage of an anonymous mass of arrogant tourists, is replaced by the new images of a tourism “shared”, in which the cultural differences are respected.<sup>1</sup> Tourists, now, should adapt to the culture of a new country: in this perspective culture and tourism are useful ideas in defending the dream of a new, social unity. It is also important that the request of culture has not particularly suffered from the crisis in the tourist sector, crisis determined by terrorist attacks in 2001.<sup>2</sup> On the contrary, cultural tourism maintained its level, having represented a concrete reason of economic growth and urban qualification. Although the growing request of cultural tourism defines a concrete activity for governors and entrepreneurs,<sup>3</sup> the results of this activity are not always satisfactory.<sup>4</sup> In particular, it is clear that the most dynamic areas are those in which the entrepreneurial activity is connected with other elements, such as:

- Marketing of the environmental and historical quality of a country;
- Effective entrepreneurial and administrative culture, which could emphasize the quality (and not the quantity) of the organization of services;
- Public and private projects to promote the typical productions of a region;
- Good accessibility of a country, facilitated by effective infrastructures which must not damage the beauty of natural environment.

Without these elements, the historical heritage, even if valued, is not able to attract important tourist-flow. On the other hand, considering the nature often immaterial of the cultural heritage, it is necessary to pursue a wise policy, which could guarantee a good balance between protection of resources and economic growth. A bad use of cultural goods could represent a serious menace for a country and its tourist attractions. For this reason, it is important to



control the quantity of tourist-flow, avoiding a possible over-flow of tourists; on the other hand, it is also important to control the qualitative use of the resources, avoiding that incorrect activities could waste the authenticity and value of a country. Only in this way it is possible to promote a good tourist product, defending social and cultural identity of a civil community and respecting the principle of sustainable development. Furthermore, it is indispensable to have an approach which presents all the relations between “menaces” and “opportunities” of development in terms of “policy” and “actions”.

	<b>Matrix of adaptation</b>	<b>to a changeable</b>	<b>request</b>	
<b>Tendency of request</b>	<b>Menaces</b>	<b>Opportunity</b>	<b>Policy</b>	<b>Activities</b>
Development of proximity flow	Concurrency in the internal and external request for the use of resources	Better services for regional request	Monitoring actions of sustainable development	Activation of social companies, technical assistance, services for tourists
Greater frequency/smaller duration of travel	Few investment in the accommodation	Diversify the offer and plan the system of receptivity	Marketing of innovative services to harmonize the seasonal tourist flow	Advantages of taxation and funding in the renovation of the hotels
Good balance quality/price	Expulsion of marginal companies	Develop models of quality/encourage competitiveness	Create new brands and discipline the quality process	Creation of companies to innovate the product
Frequency of low/cost flights	Low profile of request	Innovation in infrastructures	Develop public transports and low/cost hotels	Network of means of transport airport/region
Frequency of last minute travel	Insufficient communication/difficulty in the attraction of tourist flow	Interaction marketing between specialized tour/operators	Online system to create flexible options of travel	Communication and marketing
Interest towards cultural and natural elements	Difficulty in the circulation of the offer	Interaction between regions and cities in the same region	Plan a calendar for the activities	Interaction between companies which organize cultural activities
Increase of request of particular and complex experience of travel	Concurrency in the internal and external request for the use of resources	Diversify and articulate the offer	Promote an economy of the experience	Funding for activities of systematic integration

**Figure n. 2.** Factors and elements of “menaces” and “opportunities” in relation to the tourist phenomenon

The situation analyzed becomes more critical in the Mediterranean Region, from North to South and from West to East. It is clear that our considerations are only general and they could work as examples: for this reason, they need to be improved in each local context, thanks to specific programs of development. It could be useful, in order to emphasize the tourist growth of the whole area, to promote a deeper collaboration between the governments of both the sides of the Basin.

### **3. Representation of the archeological heritage of the Mediterranean Region with GIS technology.**

This project is aimed at creating a database to place, manage and visualize all the tourist and archeological resources of the Mediterranean Region. The result of this research is, definitely, applying GIS technology which can guarantee a better and deeper knowledge of a country, giving not only the information, but representing also the whole context of the tourist phenomenon. The development of SIT uses ESRI technology for the client component

“ArcView 9.2.”, nowadays a standard in the global market. For the central repository of data, the platform of the program is Microsoft Access, database on which there are both geographic elements (administrative limits, road graphs, etc) and alphanumeric elements. This peculiarity follows the latest evolution of GIS technology: the “geo-database”, the extension of the traditional model RDBMS towards the storing of geographical data, in vectorial format or Raster (photos, graphs, grids). Determining the type of information to include in the papers was the preliminary problem, solved by the National Management who went on with some analytic experiments. The project started from here and included the creation of a database in mdb format, using the traditional scheme Entity/Responsibility and considering the Tourist Resource as the Major Entity.

#### **A) The use of Database:\***

After inserting the cd-rom into the pc, an HTML application starts automatically which is the guide to install both the software and the data. It is necessary to click on a link (at the bottom of the page, on the left) to install (free of charge) the geographic display (Arc reader) and the database. As we have indicated before, the installation of the database includes the runtime element (Ms Acces) to allow also the users who don't have the Office facilities to visualize the papers on their pc. Having finished the installation of the program, there will be new icons both on the Desktop and on the Menu of the Programs: these icons will guide towards the direct launch of the program. The window of the database has few and simple commands to insert data, visualize in 2D and 3D, exit from the application. Clicking on the useful link, you can insert data connected to the resource to classify. The format of the module is really linear and it seems like a simple information paper with some tables where it is possible to insert data. You can divide the information about the Tourist Resource in three thematic areas: historical context, geographic context, analytical description.

#### **B) Inserting data:**

To insert data, you can use the suggestions in the menu which you can open thanks to the indicator on the left bar. This system is useful when we want avoid any typing or graphic mistakes: you also need to encode separately the different choices (for example, using the code ISO for the countries of the Mediterranean area). This last code is really important not only to identify a standard system for the counties involved in the research, but also to establish a connection with GIS software. Thanks to this connection, the system compares the report of the country with the geographic data included in the component GIS of the application. Having compared the two elements, the system connects automatically the country with the tourist resource and, at the same time, it opens all the functionalities of interrogation, geographic and analytical research. The inserted elements are:

- 0Resource code
- Name of resource;
- Macro-Category:
  - 001. Historic Centre/Kasbah
  - 002. Archeological Site
  - 003. Prehistoric Site
  - 004. Church/Cathedral/Monastery
  - 005. Mosque
  - 006. Castle/Fortress
  - 007. Historic Palace
  - 008. Museum
- Micro- Category/ Historic Origin:
  - 000. Indefinite
  - 001. Etruscan
  - 002. Greek
  - 003. Roman
  - 004. Egyptian
  - 005. Carthaginian
  - 006. Arabic
- Micro-Category (temporal reference)
  - 000. Indefinite
  - 001. Ancient
  - 002. Medieval
  - 003. Modern
  - 004. Contemporary
- Country with ISO classification (3 characters):
  - Albania (ALB)
  - Cyprus (CYP)
  - Algeria (DZA)
  - Egypt (EGY)
  - Spain (ESP)
  - France (FRA)

Greece (GRC)  
Croatia (HRV)  
Israel (ISR)  
Italy (ITA)  
Lebanon (LBN)  
Libya (LBY)  
Morocco (MAR)  
Malta (MLT)  
Syria (SYR)  
Tunisia (TUN)

- Administrative area;
- Location;
- Geographic Location;
- “Easting/Northing”;
- Tourist Basin.
- Textual Analysis.

Having completed the insertion of data and having saved the database, an automatic function of updating immediately shows the tourist resource and its geographic analysis.

In particular:

- a) if we have the geographic co-ordinates, the system will interpret them, putting the resource in its geographic location and creating a tag with its name. We could visualize all in 2D or 3D.
- b) if we don't have the geographic co-ordinates of the resource, we will leave these spaces empty and save, at the same time, all other information. The system will complete this paper, matching the resource with its country and not with a specific location.<sup>5</sup>

The project was structured to limit the visibility into definite scales (from 1:... to 1:... ) and to select the best level of zoom automatically (for example, the level “Urbanized” is visualized directly from a scale of 1:500.000). The graphic aspect, on the other hand, was selected to facilitate the reading of geographic features (railways, etc...).

From the interface of the display, you can do these actions:

- Identify the geographic element selected;
- Research values within the geographic features;
- Draw on the map;
- Analyse the map with tools of zooming and panning;
- Print and export the map in bitmap format;
- Use tools to measure distances;
- Position a point identified by its geographic co-ordinates.
- Use hyperlink functions.

The tables of the database cannot be visualized but they can be used with GIS software. In this way, when we analyse a country, the system gives the information about all the resources that are included in its area. In case we are studying a resource in a specific point, the system gives back a symbol and a tag, giving also the opportunity to access, thanks to a hyperlink, another document or a URL external from the project.

\*by Dr. Carlo De Luca, technical official, charged with SIT development.

**Conclusions.** This experimental project is realized in the FIRB program and is financed by MIUR: the project is carried out by a Group of Research, co-ordinated by Prof. Tullio D’Aponte, Director of the Unit DADA (University “Federico II”). The project also involves three other Universities (University of Sannio, University of Salento, University of Catania) and aims at an exact classification of the cultural offer in the Mediterranean Area, giving also suggestions for a new valorisation of the area. These ideas are strongly linked with the economic system of each country and its characteristics of entrepreneurial competitiveness. In the future, this project will discuss the tourist policies realised by national governors, giving also details about the areas of active or receptive tourism in the Mediterranean Region and the interactions between the local tourist system and the international tour-operators.

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<sup>1</sup> The Ethical Chart of Cultural Tourism, written in 2000 by the European Observatory on Cultural Tourism, says that "cultural heritage is able to rediscover common characters which make the human dialogue between different civil communities easier".

<sup>2</sup> The contribution of cultural tourism to the Italian National GDP is 1.3% and covers 15% of all the tourist system, (which represents 5.6% of Italian GDP). The international Italian image is deeply linked with the idea of "Italian Lifestyle". This Lifestyle is based on a great cultural heritage, connected with good weather, good food, particular traditions and folkloristic elements: for this reason, a lot of foreign tourists come to Italy. A research, carried out in 2005 by ENIT, shows that cultural tourism determines a great increase of arrivals. Tourists who come to Italy for cultural reasons of travel are from USA, Spain and Portugal (80%), Japan (85%), Switzerland and France (52%), Holland and Scandinavia (60%), Belgium and Luxembourg (40%), India (70%). The Italian Brand has reached a great position in the international tourist market, even though, in recent years, France and Spain have been considered as two interesting destinations for cultural tourism. Recently, Eastern countries and the countries which entered the EU are beginning to realize a process of rediscovering, thanks to the cheap flight connections (low/cost companies) and the good hotel accommodation. A weak point of our Italian tourist system is represented by an insufficient diversification of the offer and the connected facilities.

<sup>3</sup> It is praiseworthy that cultural policy and the tourist system have tried to find a common point of reference in the Cultural Agreement, established by local governors in 2003. The document affirmed the common will of «making the cultural values stronger, considered as the best way to guarantee the social and democratic development. Culture and tourism could promote the wellbeing of young generations, creating, thanks to a wise marketing, sustainable development and enhancement of artistic, natural and folkloristic heritage».

<sup>4</sup> In Italy the activities of promotion of cultural tourism are developed especially in some regions, while in other areas they seem to be particularly weak.

<sup>5</sup> All the files of these data are property of ESRI and they are commercialized under the name «ESRI data and maps».



# ARCHITECTONICAL AND ARCHAEOLOGICAL HERITAGE GIS-BASED RISK MAP OF HIGH AGRI RIVER VALLEY (SOUTHERN ITALY)

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## Abstract

This paper is part of a wider research project on “Territory safeguard and cultural heritage conservation in Basilicata in relation to landscape development and geomorphological risk factors” carried out by National Research Council-IBAM in the high Agri river valley, southern Italy. The whole architectural and archaeological heritage of several urban centers has been identified, analyzed and catalogued in a geodatabase, in order to structure a webGIS platform.

The project concerns a thematic that has a regional and national scale of importance and its topic is the defense and the conservation of Cultural Heritage (historical, monumental and archaeological sites). The aim is to start analyzing landscape dynamics, to compare them with natural and anthropic transformations and finally to evaluate the impact caused by extreme natural events, such as landslides, floods or earthquakes, on monumental sites and buildings.

The main aim of this project, focused on the case study of Marsico Nuovo Municipality, is to define the Cultural Heritage (architectonical and archaeological) risk map, which is the necessary basis to plan interventions of preservation and conservation of that Cultural Heritage mainly exposed to natural risks. The study was finalized to individualize the historical and architectural heritage, expression of structural vulnerability  $V$ , as well as to map the landslide phenomena as expression of hazard  $H$  natural factor. The overlapping of these two different levels permitted to defining the risk map using a matrix.

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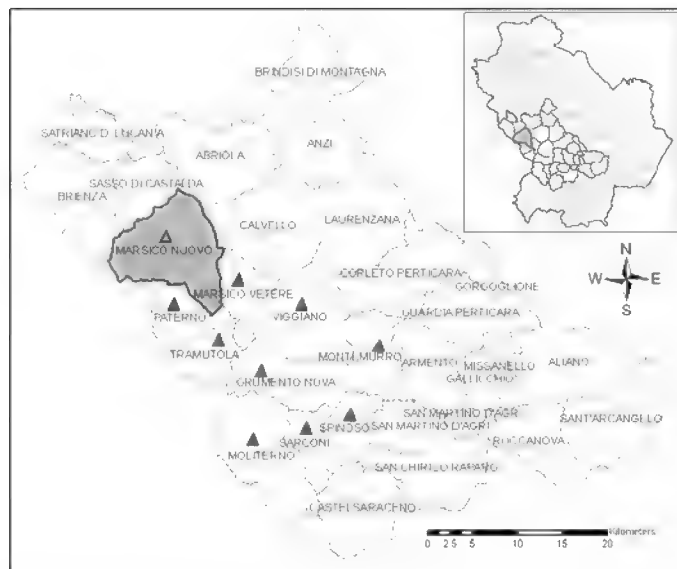
## 1. Introduction

This paper summarize the results of a project focused on "Territory safeguard and cultural heritage conservation in Basilicata in relation to landscape development and geomorphological risk factors". It is included in a wider research program for the environmental monitoring of several built-up areas and historical centres in Basilicata region (southern Italy) at present involved in oil mining and potentially exposed to natural geological risks such as seismic or hydrogeological ones. Catastrophic effects should be considered, in fact, in a global vision, consequently the analysis of the natural events impact on cultural heritage should be evaluated. This is particularly important for the conservation of Italian Cultural Heritage, because it is unique for typology and quantity, so its environmental context can't be left out of consideration.

Among all the municipalities considered for this study, ten territories of high Agri river valley, characterized by a marked historical, architectural and archaeological heritage, have been selected (Figure 1).

The selected sector covers an axial zone of southern Apennines that is characterized by high uplift rates, neotectonic activity and high grade of seismic hazard.

In the case study, therefore, the analysis of the historical heritage is the expression of the vulnerability, while a landslide hazard zonation, carried out according to Van Westen's method (Van Westen, 1993), expresses the hazard level.

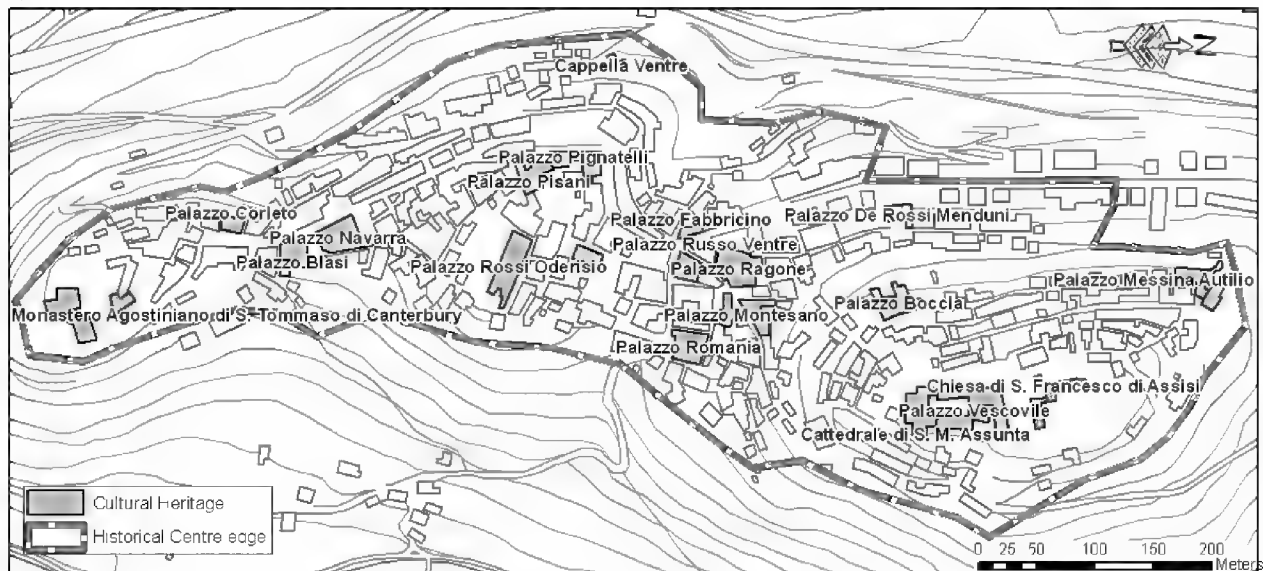


**Figure 1** – The study area (Marsico Nuovo, in grey) and the interested Centres (grey triangle).

## 2. The analysis of architectural heritage

The analysis and cataloguing of the historical and architectural heritage (heritage in urban area and extra-urban territory) in the study area were carried out according to the ICCD (Italian Centre of Catalogue and Documentation) schedule A criteria.

Then analysed data were georeferenced in the Gauss-Boaga system and put in a geodatabase to allow the following overlapping phase with hazard areas. In the geodatabase many information were entered, such as normative references, obligations, register data, quality and typology of materials, conservation and deterioration status (Figure 2).



**Figure 2** – The historical centre, monuments and buildings of Marsico Nuovo town.

## 3. The definition of natural risks

In order to get a heritage risk map, the hazard and vulnerability parameters have been considered. In particular, to evaluate the *vulnerability* the seismic damage of buildings, surveyed during the earthquake occurred on November 23rd 1980 in southern Italy, was considered, by attributing to each building a macro-seismic damage level according to European macro-seismic scale EMS (Gründal, 1998), characterized by five main levels (D<sub>1-5</sub>), using the fieldwork census after the earthquake and the description of damages by Frattani (1982) and Proietti (1994). They refer, respectively, to the damages of the Monumental Heritage in Basilicata that were analysed by Superintendence of Environmental and Architectonical Heritage, and to the damages of cultural heritage with their conservative restoration (Figure 3).

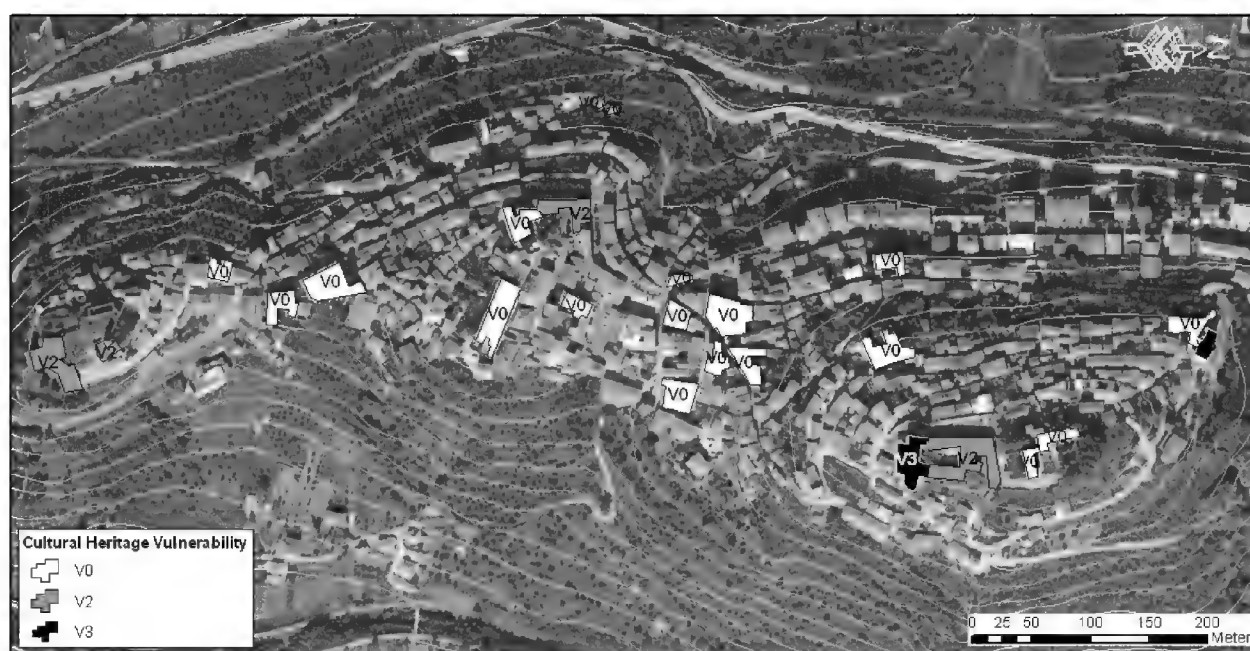
SHAPE *	Numero catalogo generale *	SHAPE Length	SHAPE Area	Denominazione	Provincia	Comune	Danno terremoto 1980
Polygon	00000046	70,40322	266,024349	Chiesa di S. Michele	Potenza	MARSICO NUOVO	D4
Polygon	00000054	27,801257	46,875231	Cappella Ventre	Potenza	MARSICO NUOVO	D0
Polygon	00000061	80,939155	393,701848	Palazzo Russo Ventre	Potenza	MARSICO NUOVO	D0
Polygon	00000070	308,081276	1498,222801	Palazzo Vescovile	Potenza	MARSICO NUOVO	D2
Polygon	00000048	101,803199	380,324052	Chiesa di S. Francesco di Assisi	Potenza	MARSICO NUOVO	D0
Polygon	00000059	132,543717	1012,313696	Palazzo Ragone	Potenza	MARSICO NUOVO	D0
Polygon	00000058	129,139711	520,079105	Palazzo Montesano	Potenza	MARSICO NUOVO	D0
Polygon	00000057	87,153118	349,538352	Palazzo De Rossi Menduni	Potenza	MARSICO NUOVO	D0
Polygon	00000062	55,732775	136,985553	Palazzo Fabbricino	Potenza	MARSICO NUOVO	D0
Polygon	00000055	135,890988	552,413779	Palazzo Messina Autilio	Potenza	MARSICO NUOVO	D0
Polygon	00000060	108,619544	665,865711	Palazzo Romania	Potenza	MARSICO NUOVO	D0
Polygon	00000053	24,789859	37,613628	Chiesa di S. Rocco	Potenza	MARSICO NUOVO	D0
Polygon	00000052	90,082351	355,81444	Chiesa di S. Marco	Potenza	MARSICO NUOVO	D0
Polygon	00000051	67,683539	215,323044	Chiesa della Madonna del Carmine	Potenza	MARSICO NUOVO	D3
Polygon	00000050	170,233378	1000,695051	Monastero Agostiniano di S. Tommaso di Cant	Potenza	MARSICO NUOVO	D3

Record: 167 Show: All Selected Records (0 out of 345 Selected) Options

**Figure 3** – Attributes table in which each historical building is inserted with the indication of macro-seismic damage for 1980's earthquake.

Every damage level corresponds to a seismic vulnerability level of the buildings, so  $V_1$  stands for a low vulnerability level and corresponds to damage level  $D_1$ ,  $V_2$  stands for a medium vulnerability level and corresponds to the damage levels  $D_{2,3}$ ,  $V_3$  is the high vulnerability level, that corresponds to the damage levels  $D_{4,5}$  (Figure 4).

To evaluate hazard, firstly an inventory landslide map has been realized. Landslide phenomena in Marsico Nuovo, were detected, as well as in the ten chosen municipalities of high Agri River valley, the geomorphological survey permitted to detect 14 inactive, 65 dormant and 32 active in the last seasonal phase landslides on a total of 137 mapped.



**Figure 4** – Vulnerability levels of Architectonical Heritage in Marsico Nuovo.

A landslide hazard zonation was obtained with Van Westen's method (Van Westen, 1993) according to the following steps:

- selection of critical factors to describe and model landslide phenomena; in this study lithology, land cover, slope, aspect, land curvature, distance from fault and distance from rivers were considered;
- calculation of a susceptibility index  $I_i$  for each factor; it expresses how much the single factor weights in landslide hazard.  $I_i$  is calculated with the equation (1):

$$I_i = \ln \frac{(X_i / S_i)}{(S / N)} \quad (1)$$

where,

- $X_i$  is extension of zones where, at the same time, there are the  $i$  factor and mass movement;
- $S_i$  is total area of the  $i$  factor in the study region;

- S is total area with landslide occurrences;
- N is the area of the study region.

Since each  $I_i$  calculated represents landslide probability depending the  $i$  factor, total hazard H is equal to expression (2).

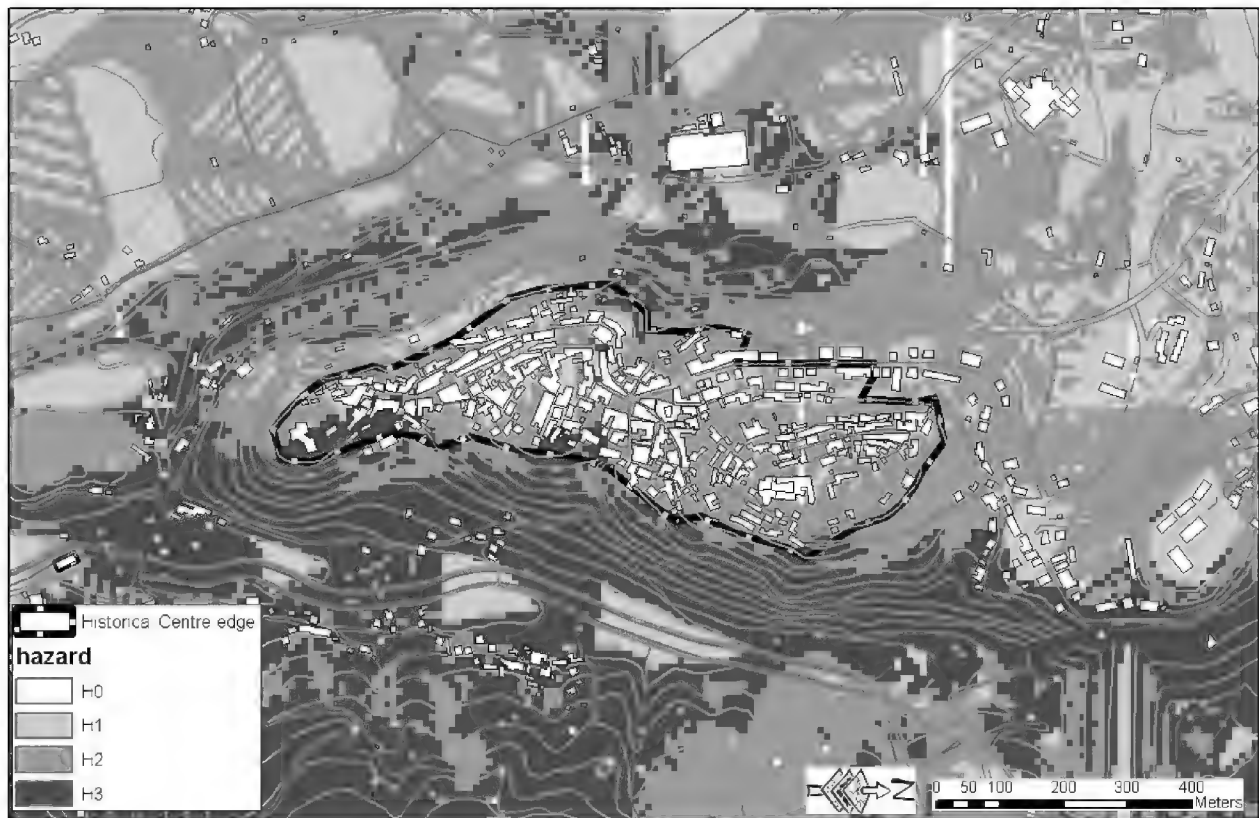
$$H = \sum_{i=0}^n X_{ij} I_i \quad (2)$$

where:

- $X_{ij}$  is equal to 0 if the  $X_i$  factor is not present in the pixel j considered, otherwise it is 1.
- n is the number of factors considered.

A hazard level (H) has been assigned to the map obtained and reclassified in the following way (Figure 5):

- $H_0$  is the very low hazard level for areas with  $H \in [-10.81; -5.4[$ ;
- $H_1$  is the low hazard level for areas with  $H \in [-5.4; 0[$ ;
- $H_2$  is the medium level for areas with  $H \in [0; 3.4[$
- $H_3$  is the high level for areas with  $H \in [3.4; 6.9]$ .



**Figure 5** – Landslide Hazard map.

#### 4. Cultural Heritage Risk Map

The Architectonical Heritage Risk Map has been obtained by overlapping vulnerability levels (V) and hazard levels (H) which had been previously defined (Figure 5).

To define the risk level for all the areas of the study and for each single building it has been determined a matrix (Figure 6) that shows the intersections of four hazard levels ( $H_{0-3}$ ) with vulnerability levels ( $V_{0-3}$ ).



		Vulnerability (Damage earthquake 1980)			
		V0	V1	V2	V3
Hazard	H0	R0	R1	R2	R3
	H1	R1	R2	R3	R4
	H2	R2	R3	R4	R5
	H3	R3	R4	R5	R6

**Figure 6** – Matrix for the valuation of geological risk levels of the historical and architectonical heritage in study areas.

The study permitted to obtain detailed information about the exposure to natural risks of Cultural Heritage (Figure 7), which had been analysed in high Agri river valley. It can represent a methodologically deepened study respect to the Risk Map proposed by the Italian Centre of Restoration (ICR), that does not show the landslide geomorphological hazard and considers the cultural heritage equally exposed to macro-seismic hazard on the whole territory, without considering the local geological and geomorphological features and the behaviour of the single buildings to the seismic events.



**Figure 7** – Results obtained after GIS analysis: different risk level interesting cultural heritage in Marsico Nuovo.

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## GIS AS A TOOL FOR THE CONTINUOUS DOCUMENTATION: FROM RESTORATION OF THE HOLY SHROUD CHAPEL IN TURIN TO A COMPLETE MANAGEMENT SYSTEM

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**Keywords:** GIS, DOCUMENTATION, RESTORATION, CH MANAGEMENT, OPEN SOURCE

On April 12th 1997 a fire completely destroyed the Holy Shroud Chapel in Turin. The Chapel designed by Guarino Guarini in 1667 is now under restoration and probably in 2011 it will be open to the public.

During the first seven years a big documentation process has been promoted by the Italian Ministry of Cultural Affairs in order to correctly plan restoration both of the structural and decorative parts. To manage the big amount of collected data a special WebGIS, completely based on Open Source solutions, has been implemented. The data have been inserted in a geo-referred geometric model of the Chapel. All the specialists involved in restoration used these data by making queries and analysis on the database.

The paper proposes a possible integration of AGR by collecting useful data from structural and decorative restoration works able to build up a complete knowledge system able to support the following phases of management and maintenance. Structural elements with their mechanical properties after the restoration will be recorded and all the materials and technique used for the restoration will be saved in order to give to the future managers the possibility to monitor the stability of the structure also considering the seismic attitude on the site.

A specific monitoring system will be placed and all the sensors will send the day by day information to the GIS in order to point out possible critical conditions which need rapid interventions in order to guarantee safety conditions for the structure itself and for visitors.

The inner surface of the Chapel has been subdivided into more than 6000 elementary elements. Each of them will require different restoration approaches. Decorative restoration will be documented in order to know the materials used to rebuild every elementary elements. These information will help the managers to correctly plan the maintenance activities and future heavy restoration works. The selection, organization, recording and management of the data will be developed by following the suggestions coming from RecorDIM initiative and will formed a step forward a complete documentation activity for Cultural Heritage.

The realization can be seen as a common platform to develop simple GIS structure able to manage all the documentation data for Cultural Heritage objects.

## SESSION C - LIFE SCIENCES, PERFORMING ARTS

## **SESSION C1 - GENETICS, ETNO ANTHROPOLOGICAL HERITAGE: CONTINUITY IN THE MEDITERRANEAN BASIN**

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### **MOLECULAR IDENTIFICATION OF INFECTIOUS DISEASES IN ANCIENT MUMMIES AND SKELETONS**

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The molecular identification of infectious diseases in skeletal and mummified human remains allows a unique insight into the presence, frequency and evolution of pathogens in ancient populations. The analysis of ancient DNA, including extraction, amplification and characterization of specific DNA fragments, made it possible to detect a wide range of bacterial, protozoal and viral infections in tissue samples of mummies and skeleton from different time periods and geographic origins. In contrast to other paleopathological methods, such as morphology, radiology and histology, the ancient DNA approach unambiguously detects pathogens, even in unclear cases or such without any visible morphological alterations. In addition, the genetic structure of the pathogens can be further evaluated, in order to reconstruct evolutionary pathways and indicate the way of transmission and spreading of diseases in ancient and modern times. A major problem in ancient DNA work is the risk of contamination and the production of non-specific results. Therefore, ancient DNA facilities have to be equipped with specialized laboratories in which only ancient material is processed and any contact with modern DNA can be strictly avoided.

In this paper the most important findings of ancient pathogen DNA will be presented and the methodological approach for the detection of pathological conditions in human remains will be reviewed. Paleomicrobiology has the capability to significantly contribute to a better understanding of the evolutionary mechanisms of infectious diseases and their impact on past human populations. Nevertheless, major attention has to be drawn to the avoidance of contamination and the authenticity of the results. The data obtained from paleomicrobiological studies represent an important addition to recent scientific work in the fight against infectious diseases. In the future, it can be hoped that the analysis of ancient pathogen DNA can contribute to the prevention, treatment and possibly even eradication of infectious diseases, such as tuberculosis, leprosy and malaria.



# BONE MICROSTRUCTURE OF ANCIENT EGYPTIANS FROM GIZA OLD KINGDOM

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*Biological Anthropology Department, Medical Research Division,  
National Research Centre, Egypt*

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## Abstract

It has been inferred that histological preservation of bone is a good predictor of the recovery of DNA from human ancient remains. The aim of this study is to investigate the bone microstructure of ancient Egyptian human remains excavated from the Giza Necropolis. The material consisted of 74 skeletons (43 males and 31 females) from two different social classes (high officials and workers) and belonged to the Old Kingdom (2687–2191 BC). In this study we employed light and scanning electron microscopic (SEM) analysis to determine the state of preservation of the cellular architecture and ultrastructure of hard tissue (bone and teeth). Results showed that the preservation of bone was well for both high officials and workers. Significant decreases of histological parameters by age were observed in both sexes. SEM demonstrated that the horizontal trabeculae were more affected than the vertical trabeculae in some fragile cases. The study suggests that the soil and burial environments of this archaeological site may play important role for the good preservation of the bone material of ancient Egyptians. The study concludes that the preservation status of archaeological bone cannot be assessed on macroscopic appearance alone and other microscopic analyses are necessary to visualize diagenetic change in bone.

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**Keywords:** Histomorphometry, SEM, Old Kingdom, Bone preservation, Giza, Egypt

## 1. Introduction

Bone is a complex material, consisting of organized mineral and organic components. The degradation of bone depends not only on intrinsic factors such as composition, biological age [1], species [2] as well as determined by extrinsic factors such as soil pH [3], temperature, method of burial and post-depositional history. The diagenesis of bones is mediated by microorganisms, the presence of which has a profound influence on the bone preservation potential. Histology and Scanning electron microscope are relatively easily applied techniques that allow several degradation phenomena to become visible in a qualitative or semi-quantitative way [4, 5, 6]. Ancient Egyptians civilization is mainly famous for its huge buildings as the pyramids, temples and monumental tombs. The building of the pyramids, the most immense feats of architecture of any time or place, was carried out in the Old Kingdom period from the ancient Egyptian history. Living bone consists of three major components: organic matter, principally proteins; mineral in the form of calcium phosphates; and water. The water contents of buried bones and the sediments that surround them play as important a role in their future integrity over archaeological time-scales as the chemistry and availability of biological fluids do during life. Evidence has suggested that water and temperature play important roles in the deterioration of human skeletons. The aim of this study is to investigate the bone microstructure of ancient Egyptian human remains excavated from the Giza Necropolis, belonged to old kingdom.

## 2. Material and Methods

The material of the present study consists of 74 skeletons (43 males and 31 females) from two different social classes (high officials and workers). The Giza group represents a very important period in the history of ancient Egypt "the pyramid builders' period". The skeletons belonged to the Old Kingdom period which started by the third dynasty and ended by the end of the sixth dynasty "2700 - 2190 BC." [7]. They were excavated from the Giza necropolis and classified into two socioeconomic classes; high officials and workers according to characters, design and contents as well as the writings and drawings on the walls of the tombs [8]. The skeletons of workers were recovered from Giza South East cemetery and those of high officials were excavated from Giza Western Cemetery. The tombs of the high officials in western cemetery are made of limestone and the mastabas are large and elaborate. The worker's tomb shafts are very poor. The archaeological material and painting found showed that it is the cemetery of the workers who shared in building up the pyramids Ancient Egyptians believed in the after life, so they equipped their tombs with funerary furniture, which reflects the socioeconomic standard of the occupant (9, 10, 11). Moreover, the design of the tombs and presence of statues and reliefs all express the socioeconomic standard of the sectors of the population.

Determination of the sex of the skeletons was carried out using the descriptive methods of both skull and pelvis [12]. Age at death was estimated using auricular surface metamorphosis [13] and from the pubic symphysis [14]. Femoral cross-sections for histology were prepared [15] with final section thickness ranged from 50 to 100  $\mu\text{m}$ . The definition for osteon fragments or complete osteons followed definition of Stout [16]. The preservation of bone

microstructure is represented by the histological index (HI) [6]. The femoral cross-section is evaluated on a scale from 0 to 5 (0 represents no original microstructure left, and 5 represents virtually perfect bone). The sections are examined for types of diagenetic change, adapted from Garland et al. (1988) [17]. Scanning electron microscope (SEM) was carried out, using the method of Mosekilde [18] and Wakley et al. [19] by scanning electron microscope “SEM” (Philips XL30).

### 3. Results

Table 1 shows age and sex distribution of ancient Egyptians from old kingdom. Results show that the mean age of death of the workers is close to that of the high officials. The Giza skeletal sample showed normal distribution of age at death in both sexes. Age at death can be used cautiously as a measure of the overall quality of life that reflects nutrition and disease within the context of given fertility rates. Table 2 shows regression formulae for calculating age at death (Y) for the Old Kingdom of ancient Egyptians, Giza for each sex and both combined. The present regression equations showed standard errors ranged from 5.47 to 6.9 years.

The Qualitative histological analysis was used to evaluate the degree of bone preservation. The sections are examined for diagenetic change. Bone sections show absence of microscopic focal destructions (Figures 1 and 2). Results showed well preserved bone in both high officials and workers. The histological index ranged from 3-4 in present samples with mean ranged from 3.3 to 4.3. Significant decreases of histological parameters were observed by age in both sexes.

Scanning electron microscopy (SEM) is used to evaluate bone ultra-structure. Figure 3 illustrates the scanning electron micrograph of a trabecular bone in an osteoporotic case, showing osteoclastic perforation of a thin horizontal trabecula. Figure 4 shows the normal enamel prism structure in a fractured etched preparation of the human molar. This result means that the diet of ancient Egyptians did not focus on very hard foods, which caused well preserved teeth.

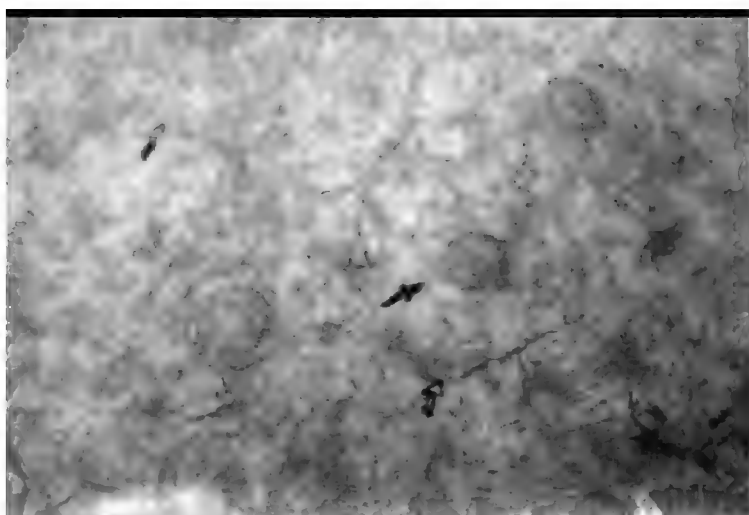
**Table 1.** Age and sex distribution of ancient Egyptians from the Giza necropolis

Age (years)	Workers		High Officials	
	Male %	Female %	Male %	Female %
20-30	20.5	24.3	5	14
30-40	41.1	35.2	40	27.9
40-50	32.4	24.3	28.3	27.9
50+	5.9	16.2	26.7	30.2
Mean age	37.35	38.24	42.66	42.44
Mean HI	3.4	3.3	4.3	4.1

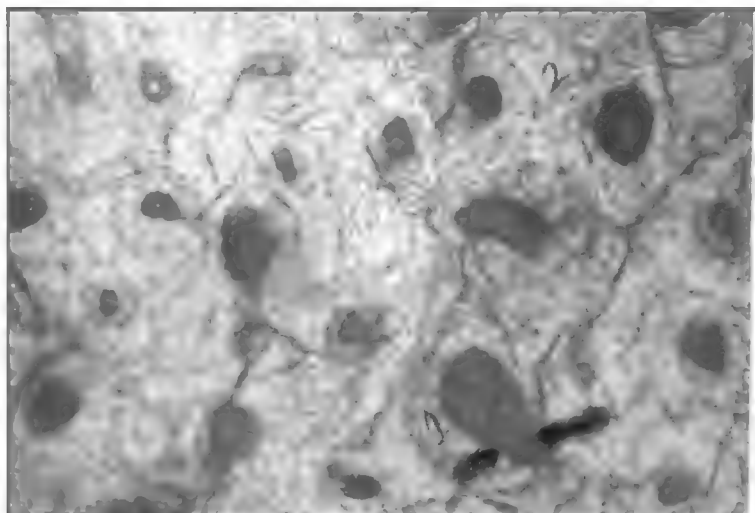
*Histological index (HI)*

**Table 2.** Regression formulae for calculating age at death (Y) for the Old Kingdom of ancient Egyptians, Giza

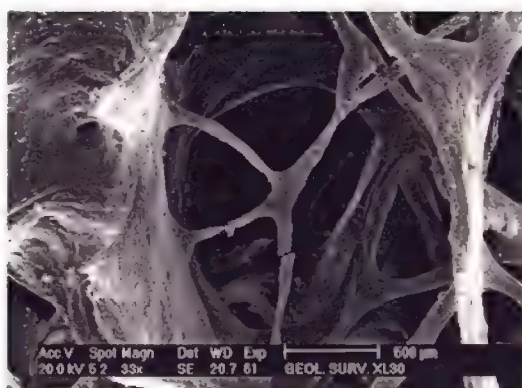
Sex	Regression	Standard error
Males	$Y = 27.57 + 1.6 (\text{resorption spaces}) + .82 (\text{secondary osteons})$	$\pm 6.927 \text{ y}$
Females	$Y = 32.44 + 1.68 (\text{resorption spaces})$	$\pm 5.47 \text{ y}$



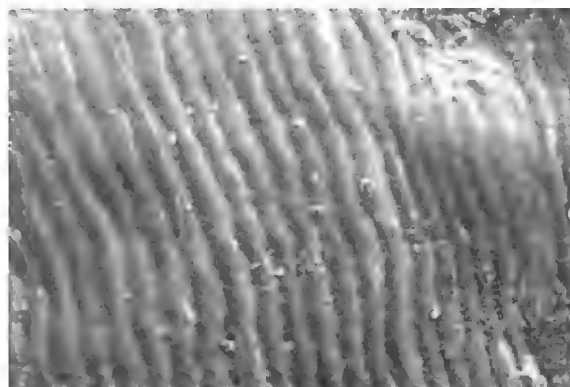
**Figure 1.** Photomicrograph of unstained transverse section of femur bone showing, complete secondary osteons



**Figure 2.** Photomicrograph of unstained transverse section of femur bone showing, complete osteons, fragmentary osteons, and resorption spaces



**Figure 3.** Scanning electron micrograph of a trabecular bone showing osteoclastic perforation of a thin horizontal trabecula (magnification: 33x)



**Figure 4.** A scanning electron micrograph showing enamel prisms in a fractured itched preparation of the human molar. Scale bar 500 µm.

### 3. Discussion

Bone is the hardest tissue in the body which can be naturally preserved for a long time after death. This time may extend to hundreds or even thousands of years. So, physical anthropologists depend on bone as a reliable source of information to reconstruct the life of prehistoric and historic populations. The physical survival of bone is integral to any kind of palaeopathological study. When assessing skeletal remains for pathological conditions, it is also important to distinguish successfully between bone lesions that arose ante- or peri-mortem as a result of disease or trauma, and damage caused by post-mortem processes taking place in the burial environment. There are two predominant mechanisms of bone degradation in archaeological soils, which may or may not proceed simultaneously. These are bacterial degradation of the tissues and chemical hydrolysis of bone collagen. In most bones from aerated soils, both mechanisms proceed simultaneously, although at different rates, and the net result is a gradual loss of collagen content over time. In this study we used two techniques to determine the state of preservation of archaeological bone. Microbial and chemical degradation is microscopic in nature and can influence the interiors of the bones as well as their surfaces.

Histology is a technique that is a relatively quick and inexpensive method, and it allows the identification of altered areas in the section. The osteon is taken as the basic structural unit (Figures 1 and 2) [20]. In the present study the standard error of estimate of the age showed acceptable values ( $\pm 7$  years), indicating the accuracy of the method and the apparent relation between macroscopic ages and histologic age estimates in the present sample. Consequently, the absence of bone microstructure destruction and the well macroscopic preservation of this sample must be caused this small difference. The present study showed a well preserved bone microstructure with HI ranged from 3 to 4 in both sexes as well as social classes. Significant decrease of histological parameters was only related to age in both sexes. Many previous studies use histology for the determination of the preservation of bone microstructure [21, 5, and 6]. Moreover, skeletons of ancient Egyptians were well preserved macroscopically, indicating the relationship between diagenetic change in the microstructure of the bone and the macroscopic and biochemical preservation of the bone. From this and other studies [22, 23], it becomes clear that bone preservation cannot be assessed on macroscopic appearance alone.

Also, the higher image resolution on the SEM gives us confidence that we can differentiate areas of interest. Because we are concerned with relative characteristics within single samples of bone, it is most important that we can differentiate and analyze areas no more than a few microns apart. The higher resolution of current SEM techniques revealed a fine structure to the microscopical focal destruction. The strength of the vertebral trabecular bone is dependent not only on bone mass, but on bone architecture. Consequently, in the present study SEM was used to assess the microarchitectural structure of bone. The present study confirmed, in a clear visual manner, the age-related changes in vertebral trabecular bone with loss of continuity caused primarily by thinning and disappearance of the horizontal struts, as is seen in vertical sections.

Results showed that the workers and high officials showed no difference in the preservation status. This may be attributed to the resemblance of the soil constitution in the two cemeteries in the Giza plateau. Some cases show signs of osteoporosis (Fig. 3), which had pathological conditions [24], and not due to the burial environment. The study suggests that the soil and burial environments of this archaeological site the Giza necropolis in Lower Egypt may play important role in the well preservation status of the excavated bone material of ancient Egyptians. Most archaeological materials have formed some sort of equilibrium with the soil environment with respect to their state of deterioration [25]. The Giza Necropolis stands on a limestone plateau overlooking the Nile Valley. It contains the pyramids of three kings, Gheops, Chephren and Mycerinus. Thousands of workmen contributed in constructing the pyramids and temples. The workmen settlement was found near the pyramid of Chephren 'IV dynasty'. It was built from stone and large enough for workmen who contributed in the construction of the pyramids and the cemeteries. The cemeteries around the first pyramid were planned to include the princes on the east side, and the high officials on the western side [8].

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## **A "VIRTUAL REALITY" FOR THE PALEOBIOLOGICAL AND ANTHROPOLOGICAL HERITAGE: NEW STRATEGIES OF SAFEGUARD, VALORIZATION, AND SCIENTIFIC EXPLOITATION FROM HIGH-RESOLUTION NON-INVASIVE ANALYTICAL TECHNOLOGIES.**

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Even though quantitatively scarce and qualitatively fragmentary, bony and dental remains usually represent the only available (palaeo-archaeo)biological evidence testifying the life of past human populations in a given region of the world. The appropriate safeguard, valorisation, and subtle exploitation of this unique heritage for scientific research and educational purposes (e.g., museography) is crucial when assessing complex biohistorical processes dealing with intermittent peopling phases, adaptative biocultural dynamics, chrono-geographical trends, and time-related microvariation patterns. The management/fruition of the anthropological heritage is affected by its intrinsic characteristics of uniqueness, fragility, and wide dispersal. While osteodental remains, notably those fossilized, are characterized by high mineral content, their handling for direct observation, analysis, reproduction, casting, display, is risky. On the other hand, there is a growing demand for access to the original specimens from the specialists as well as for public display. Additionally, as demonstrated by recent advances in developmental and quantitative morphology, a critical amount of biocultural information lies hidden within the inner structure of the mineralized tissues (cortical and trabecular bone, enamel, dentine, cementum) and its access is limited by the need to assure integrity of the specimens and by the usual noise depth resulting from taphonomic dynamics. In response to the potentially conflicting requirements of safeguard vs. fruition/exploitation of this record, advanced technologies allow by now the high-resolution reproduction (virtual and solid), of any specimen, and a new generation of non-invasive analytical tools currently grants the extraction of a wide range of morpho-structural information. Together, these approaches assure the "immortalization" of any specimen and its rendering for direct and/or virtual manipulation, exploration, exportation. In alternative to invasive approaches, which can be used only very parsimoniously in paleobiology, the increasing use of non-invasive analytical techniques (such as those based on microfocal X-ray computed tomography) capable to virtually explore, to extract, to "clean", and to finely render at varied resolutions the even noisy signature hidden in fossil specimens, has recently opened new promising perspectives in the field. Notably, this implies the 3D (vs. traditional 2D) imaging and the surface/volumetric (vs. linear) characterization of the endostructural variation. Nonetheless, a reliable investigative shift from the "container" to the "contents" does not only require new, advanced techniques (and technologies), but also new fundamental concepts concerning what (and how) should be rendered and characterized (both qualitatively and quantitatively) in routine analytical protocols. In this perspective, a long-term methodological work is still needed. Supported by: French CNRS, Univ. of Poitiers (Centre de Microtomographie), MNHN (Paris), ESRF (Grenoble), EU TNT Project, Nespos Society (Mettmann), EU Marie Curie Actions.

## THE NEANDERTHAL EXTINCTION AND THE APPEARANCE OF ANATOMICALLY MODERN HUMANS IN MEDITERRANEAN EUROPE: A VIEW FROM GROTTA DI FUMANE, NORTH OF ITALY.

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The Middle - Upper Palaeolithic shift was a crucial event intimately concerned with the Neanderthal bio-geography and the patchy scenario raised from the last, marked cultural and behavioural evolution our extinct relatives underwent during the 50-30 ky B.P. interval. In Mediterranean Europe this so considered “modern” behaviour gave rise to the Uluzzian, a cultural complex confined to central-southern Italy and Greece in consequence of archaic humans supposed contraction facing the rapid diffusion of *Homo sapiens*.

This contribution presents the first results achieved from the recent excavations carried out at Fumane Cave, a key site in the North of Italy in which it is possible to explore Neanderthal behaviour and compare it with Modern Humans and the Aurignacian record. Extensive excavations of the late Mousterian layers (units A6 and A5) and the Uluzzian layers (units A4 and A3) have brought to light different types of traces ascribable to the human occupation at the cave entrance. Moreover, the recent discovery of dwelling structures and lithic implements re-drawns this scenario and depicts the northernmost frontier to which the Uluzzian spread around the Great Adriatic Plain, a pivotal region near the western edge of the Middle Danube basin where last Neanderthals were present and beared strictly different cultural items. Currently, this archive is a part of the Lessini Regional Natural Parc and frames in the project of Cultural heritage Governance implemented by the Parc, the Municipality of Fumane and local promoters. Small targeted groups visit the cave all the year and also during the fieldwork season.

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Peresani M., 2008, A new cultural frontier for the last Neanderthals: the Uluzzian in Northern Italy. *Current Anthropology*, 49/4, pp. 725-731.



# THE NEOLITHIC REVOLUTION AND ITS REPERCUSSIONS IN THE MEDITERRANEAN BASIN: A STUDY THROUGH DENTAL MORPHOLOGY

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## Abstract

The present study wishes to infer in the relationships and interchanges of circum-Mediterranean populations throughout time and space. In particular it wishes to, on one side, assess the diachronic relations among the different populations that have, in time, inhabited the region; and on the other, evaluate the relations each of these groups had with those in their chronological or geographical vicinities. Dental morphology was the methodology adopted, for studies on historical and even fossil remains have clearly demonstrated the great validity and potential of such an approach in the study of human variation and have indicated it to be, potentially, one of the most adequate physical anthropological approaches in population studies.

The Neolithic revolution has determined indisputable changes in subsistence throughout the Mediterranean. Even though there is general consensus regarding a Near Eastern descent for the European Neolithic, its modalities and extent are, however, unfortunately still far from resolved. Two principal, but extremely dissimilar, scenarios have, in fact, been hypothesized: demic diffusion and cultural transmission; the first envisaging a change in the region's genetic pool and the second envisaging population continuity. In order to establish if, in the region, the gene flow has been continuous or if, on the contrary, migrations have caused strong discontinuities, the present study addresses the bearers of the Neolithic culture and establishes the relations both amongst them and with the populations that preceded them. Furthermore, the present study wishes to establish if the adoption of a Neolithic subsistence along the southern shore of the Mediterranean was an independent process or if, on the contrary, it was part of a wider phenomenon which was interesting, from the Near East, a great portion of the Old World.

The results, indeed, seem to strongly suggest the transition to a Neolithic subsistence was accompanied by consistent population replacement and that the Neolithic revolution spread in different directions. In particular, they seem to indicate routes along the northern and southern coasts of the Mediterranean, towards the Arabian Peninsula and along the shores of the Nile valley and from there to Kenya.

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**Keywords:** dental morphology; biological affinities; Neolithic; Mediterranean basin

## Introduction

The present study wishes to infer in the relationships and interchanges of circum-Mediterranean populations throughout time and space. In particular it wishes to, on one side, assess the diachronic relations among the different populations that have, in time, inhabited the region; and on the other, evaluate the relations each of these groups had with those in their chronological or geographical vicinities. Dental morphology was the methodology adopted, for studies on historical and even fossil remains have clearly demonstrated the great validity and potential of such an approach in the study of human variation and have indicated it to be, potentially, one of the most adequate physical anthropological approaches in population studies <sup>1</sup> [Scott GR., Turner II CG. (1997) *The anthropology of modern human teeth. Dental anthropology and its variation in recent human populations*, Cambridge University Press, Cambridge, 382 p].

The present study addresses the bearers of the Neolithic culture and establishes the relations both amongst them and with the populations that preceded them in order to establish if, in the region, the gene flow has been continuous or if, on the contrary, migrations have caused strong discontinuities. Furthermore, it wishes to determine if the adoption of a Neolithic subsistence along the southern shore of the Mediterranean was an independent process or if, on the contrary, it was part of a wider phenomenon which interested, from the Near or Middle East, a large portion of the Old World.

## The Neolithic Revolution

The Neolithic revolution has determined indisputable changes in subsistence throughout the Mediterranean. Even though there is general consensus regarding a Near or Middle Eastern origin of the European Neolithic <sup>2</sup> [Childe GV. (1928) *The most ancient east: the oriental prelude to European history*, P. Kegan, Trench, Trubner, London, 326 p], <sup>3</sup> [Binford LR (1968) in: *New perspectives in archaeology* (SR. Binford, LR. Binford, eds), Aldine, Chicago, 313–341 p], its modalities and extent are still far from resolved. Two main, but very dissimilar, scenarios are currently being evaluated: demic diffusion and cultural transmission; the first drives a change in the region's genetic



pool and the second, population continuity. Initially advanced by Ammermann and Cavalli-Sforza<sup>4</sup> [Ammerman Albert J, Cavalli-Sforza Luigi L (1971) *Man*. 6, 674–688],<sup>5</sup> [Ammerman AJ, Cavalli-Sforza LL (1973) in: The explanation of culture change (C. Renfrew, ed), Duckworth, London, 343–357 p], the demic diffusion model (or wave of advance) assumes technological advances must have consented a greater exploitation of the environment and, accordingly, caused an increase in population size. Consequently, these populations must have necessarily expanded into new territories where they may have encountered other populations with which there may have been admixture. The acculturation model (or cultural transmission model)<sup>6</sup> [Zvelebil Marek, Zvelebil Kamil V (1988) *Antiquity*, 62, 574–583], counterpoints the main assumptions of the demic diffusion model. It presumes a technological migration with little or no admixture with its carriers.

Different, also very recent, studies, state that the spread of the Neolithic culture in South Eastern Europe occurred predominantly due to acculturation rather than via genetic amalgamation<sup>7</sup> [Battaglia Vincenza, Fornarino Simona, Al-Zahery Nadia, Olivieri Anna, Pala Maria, Myres Natalie M, King Roy J, Rootsi Siiri, Marjanovic Damir, Primorac Dragan, Hadziselimovic Rifat, Vidovic Stojko, Drobnic Katia, Durmishi Naser, Torroni Antonio, Santachiara-Benerecetti A Silvana, Underhill Peter A, Semino Ornella (2009) *Eur. J. Hum. Genet.* 17, 820–830],<sup>8</sup> [Mirabal Sheyla, Varlhenb Tatjana, Gayden Tenzin, Regueiro Maria, Vujovic Slavica, Popovic Danica, Duric Marija, Stojkovic Oliver, Herrera Rene J (2010) *Am. J. Phys. Anthropol.* In advance of print]. Armelagos and Harper<sup>9</sup> [Armelagos George J, Harper Kristin N (2005) *Evol. Anthropol.* 14, 68–77], believe acculturation to have prevailed in Africa and Asia, for they seem to have possessed their own domestication centres, but that the different lineages of domesticates suggest a single wave of advance of farmer-pastoralists from the Middle Eastern Fertile Crescent into Europe, perhaps with replacement of the autochthonous inhabitants. Other studies seem to concur that the introduction of farming in the circum-Mediterranean area must have resulted from both the adoption of agriculture by local hunter-gatherers and the process of colonization by farmers migrating into the continent<sup>10</sup> [Price TD (2000) in: *Europe's first farmers* (TD. Price, ed), Cambridge University Press, Cambridge, 301–318 p] and that there must have therefore been, to some extent, admixture; even though its supposed entity may vary substantially in the different regions and according to the different ones. One study, regarding the origin of agriculture in Italy<sup>11</sup> [Coppa Alfredo, Cucina Andrea, Lucci Michaela, Vargiu Rita (2009) *Am. J. Phys. Anthropol.* 133, 918–930], concludes, on the basis of dental anthropology, that the Paleo-Mesolithic peopling of Italy was followed by a later Neolithic gene flow that altered, consistently, the biological structure of the native Italian populations and that, in agreement with Price, the replacement does not appear to have been complete. There are, moreover, different studies clearly in favour of a scenario in which subsequent migrations, in different directions from a common point of origin, brought with them – and therefore to both Eurasia and North Africa – the techniques, the basic domesticates and also the proto-language ancestral to the ones now characteristic of the region<sup>12</sup> [Barbujani Guido, Pilastro Andrea, De Domenico Silvia, Renfrew Colin (1994) *Am. J. Phys. Anthropol.* 95, 137–154]<sup>13</sup> [Cavalli-Sforza Luigi L, Piazza Alberto, Menozzi Paolo, Mountain Joannah L (1988) *PNAS* 85: 6002–6006],<sup>14</sup> [Renfrew Colin (1991) *Cam. Arch. J.* 1, 3–23],<sup>15</sup> [Renfrew Colin (1992) *Man* 27, 445–478]

## Materials And Methods

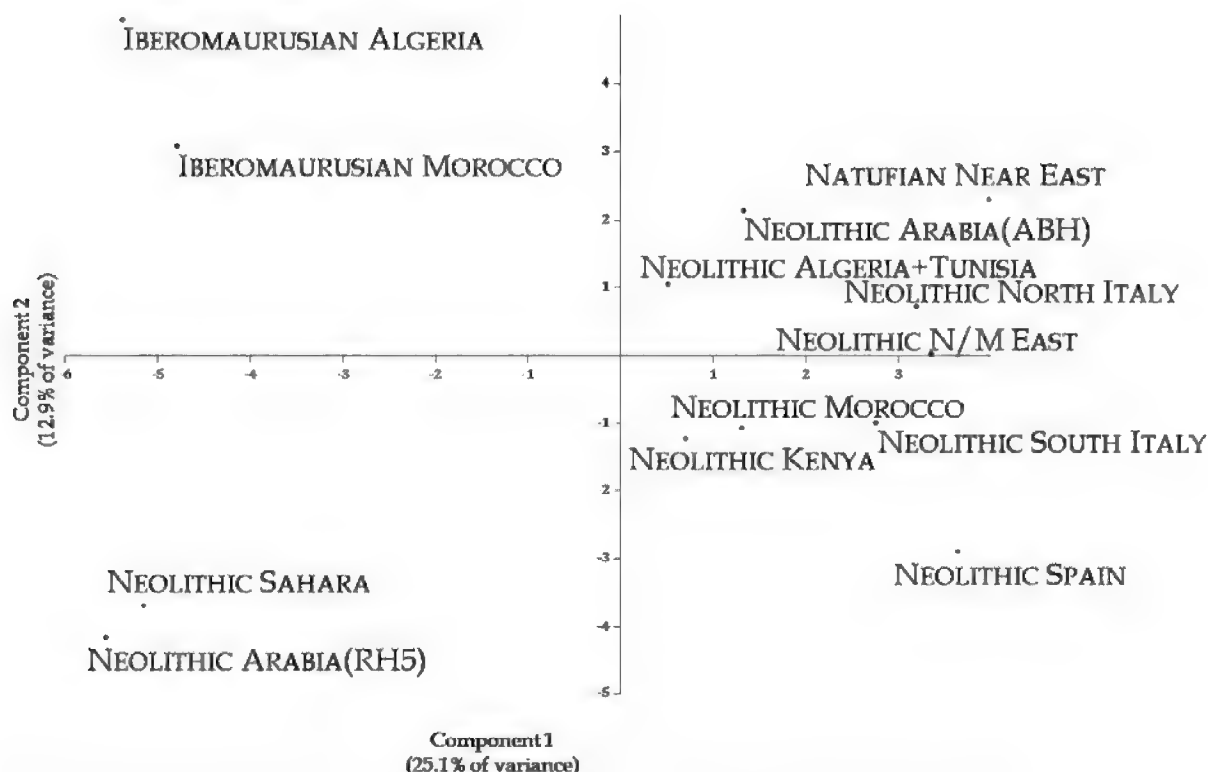
The present study analysed 1,510 individuals from Southern Europe, Africa, the Near/Middle East and the Arabian Peninsula dated from the Late Pleistocene to the 4<sup>th</sup> Millennium BC. In particular, it includes dental morphological data scored on 8,888 teeth on the basis of the “one-tooth-per individual” count method (a method which underestimates the actual number of teeth scored for it considers only one antimer per individual, even when data was scored on both).

The samples were assigned chronologically to two different phases so as to confirm the possible continuity in the region from the advent of the Iberomaurusian and Natufian cultures to the end of the Neolithic one: a first phase comprising all the populations that certainly preceded the spread of the Neolithic and a second with of all the samples dated from 10,000 BP (date marking the end of the Last Glacial Maximum and the recession of the ice caps) to 3,000 BP. For simplicity, we here refer to the groups of this later period as Neolithic for indeed the greatest characteristic of this period is the appearance and subsequent instauration of Neolithic cultures throughout the Mediterranean basin. It is, however, merely a manner of pinpointing the time period and not a cultural attribution. The samples of each of these chronological phases were then pooled according to geographic criteria. 13 different groups were thus formed, three pertaining to the more ancient phase and ten to the more recent one.

Dental morphological variation was scored for all permanent teeth following the standards, for all but one trait, of the Arizona State University Dental Anthropology System (ASUDAS), as described by Turner and colleagues<sup>16</sup> [Turner II CG, Nichol CR, Scott GR (1991) in: *Advances in Dental Anthropology* (MA. Kelley, C. Spencer Larsen, eds), Wiley Liss, New York, 13–31 p]. The “mesial bending ridge”, as described by Pinto-Cisternas<sup>17</sup> [Pinto Cisternas J, Moggi Cecchi J., Pacciani E (1995) in: *Aspects of Dental Biology. Palaeontology, Anthropology and Evolution* (J. Cecchi Moggi, ed), International Institute for the Study of Man, Florence, 333–339 p] and often found in Italian populations, was the only trait adopted which does not belong to the ASUDAS. Observations were made of 29 dental characteristics and each observation was made on all the teeth for which it was applicable. When present, both sides were scored and a maximum of 89 observations per side were obtained per dentition. The 57 most representative ones were then selected for further analyses; 30 of which relative to the upper dentition and 27 to the lower. Traits were scored on a continuum but, so as to enable trait by trait comparisons and

facilitate the use of non parametric statistical analyses<sup>18</sup> [Turner II Christy G (1987) *Am. J. Phys. Anthropol.* 73, 305-321], the resulting data was reduced into presence/absence categories by using trait expression threshold levels.

Given the nature of the data and the still insufficient understanding of the precise modes of transmission, different statistical analyses were applied: principal components analysis (PCA)<sup>19</sup> [Hotelling Harold (1933) *J. Educational Psychol.* 24: 417-441, 498-520],<sup>20</sup> [Rao C Radhakrishna (1948) *J. Roy. Statist. Soc. Ser. B.* 10, 159-193]; mean measure of divergence (MMD)<sup>21</sup> [Berry RJ, Berry A Caroline (1967) *J. Anat.* 101, 361-379],<sup>22</sup> [Smith CAB (1977) *Ann. Hum. Genet.* 40, 463-479] using the Freeman and Tukey's angular transformation<sup>23</sup> [Freeman Murray F, Tukey John W (1950) *Ann. Math. Statist.* 21, 607-611] when there were less than 40 observations<sup>24</sup> [Green Richard F, Suchey Judy M (1976) *Am. J. Phys. Anthropol.* 45, 61-68]; multidimensional scaling (MDS)<sup>25</sup> [Kruskal JB., Wish M. (1978) *Multidimensional Scaling*, Sage Publications Inc., Newbury Park, 96 p] on an MMD matrix and unweighted pair-group analysis (UPGMA) on Euclidean distances. The use of different methodologies and therefore of outputs which may somewhat differ, often determines a somewhat less certain panorama. It is, however of fundamental importance for it gives a much greater strength to those trends observed throughout.



**Figure I:** Principal Components. Scatterplot showing distribution along first two components.

## Results

Principal components analysis (FIGURE I) seems to indicate the presence of a profound separation between the Iberomaurusian groups and all of the others. Most of the Holocene groups, and in particular all of the Mediterranean ones, seem to cluster and, they do so, in proximity to the Natufian Near Eastern group. The Holocene group from Kenya also clusters in their midst. Interesting is the fact that, indeed the Neolithic Moroccan group seems to show, within the cluster, greater similarities to the other Neolithic Mediterranean groups than it does to the confining one from Spain. Particularly interesting is also its great distance from the Neolithic Saharan group. This last group, in fact, distances itself greatly from all of the Holocene Mediterranean ones and shows, along its first component, greatest similarity to the Iberomaurusian Maghrebian ones.

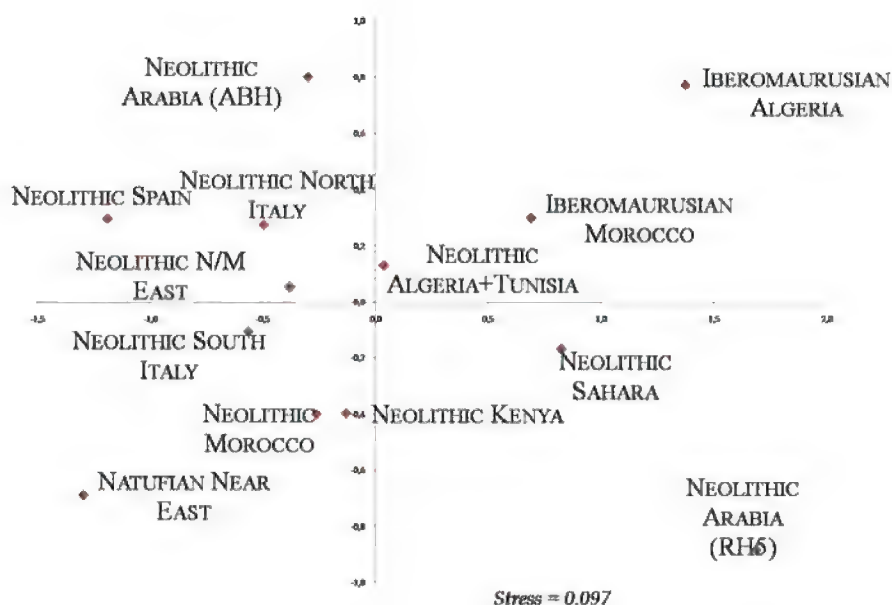
Mean measures of divergence (TABLE I) were then calculated between groups and adopted to construct a multidimensional scaling plot. The plot (FIGURE II), even though more dispersed, seems to be consistent with what observed through principal component analysis. Once again the Iberomaurusian groups tend to plot at a great distance from all of the circum-Mediterranean Holocene ones. The only group that seems to show greater similarities and that plots in the same quadrant is the Neolithic one from Algeria and Tunisia. However, its distance to the Iberomaurusian Moroccan group (the Iberomaurusian group to which it plots closest) is not significant and may therefore not be taken into account. Once again, the Mediterranean Neolithic groups tend to cluster whereas the Neolithic Saharan group and the Neolithic Arabian group of RH5 tend to plot at a great distance.

Unweighted pair-group analysis was the last statistical approach adopted. The resulting tree (FIGURE III) once again shows: a great and profound separation between the Iberomaurusian groups and all of the others as well

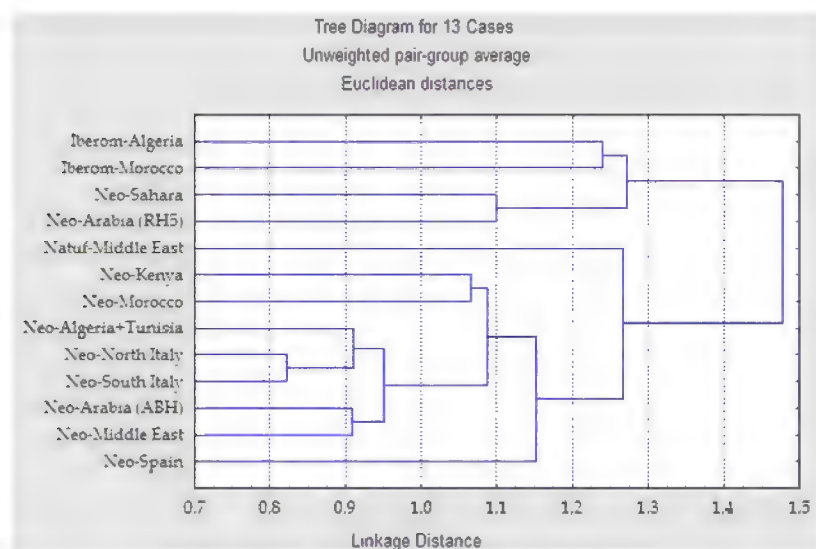
as a cluster inclusive of all of the circum-Mediterranean Neolithic groups and the Natufian one; this last showing greatest dissimilarity within the cluster.

**Table I:** Mean Measure of Divergence. The values are tabled in the lower matrix whereas the relative standard deviations are in the upper one. Significant measures ( $MMD > 2DS$ ) are indicated in bold.

	MESO-ALG	MESO-MOR	MESO-MDLE	NEO-KNY	NEO-MOR	NEO-SHR	NEO-ALG.TN	NEO-ABH	NEO-RHS	NEO-SPN	NEO-ITN	NEO-ITS	NEO-MDLE
MESO-ALG		0,031	0,017	0,025	0,022	0,016	0,021	0,016	0,016	0,022	0,018	0,016	0,030
MESO-MOR	NS-0,029		0,024	0,032	0,029	0,023	0,028	0,023	0,023	0,029	0,025	0,024	0,037
MESO-MDLE	0,251	0,189		0,018	0,015	0,008	0,013	0,009	0,008	0,015	0,011	0,009	0,023
NEO-KNY	0,160	0,075	0,080		0,023	0,017	0,022	0,018	0,017	0,024	0,020	0,018	0,032
NEO-MOR	0,255	0,100	0,164	0,016		0,014	0,019	0,015	0,014	0,020	0,016	0,015	0,028
NEO-SHR	0,112	0,034	0,179	0,038	0,050		0,012	0,008	0,007	0,014	0,009	0,008	0,022
NEO-ALG.TNS	0,113	0,034	0,120	0,015	0,012	0,042		0,013	0,012	0,019	0,014	0,013	0,027
NEO-ABH	0,163	0,081	0,148	0,098	0,110	0,109	0,058		0,008	0,015	0,010	0,009	0,023
NEO-RHS	0,164	0,120	0,380	0,167	0,232	0,129	0,180	0,286		0,014	0,010	0,008	0,022
NEO-SPN	0,261	0,168	0,157	0,061	0,111	0,107	0,081	0,125	0,294		0,016	0,015	0,029
NEO-ITN	0,167	0,097	0,099	0,048	0,054	0,080	0,027	0,059	0,248	0,036		0,010	0,025
NEO-ITS	0,193	0,071	0,089	0,043	0,062	0,063	0,046	0,077	0,215	0,030	0,038		0,023
NEO-MDLE	0,213	0,066	0,109	0,023	0,000	0,038	-0,006	0,012	0,220	0,044	0,001	-0,004	



**Figure II:** Multidimensional Scaling. Two-dimensional scatterplot.



**Figure III:** Unweighted Pair-Group Average.

## Discussion

The results obtained are both coherent and consistent throughout the statistical approaches adopted; once again indicating the validity of the approach in population studies.

The distance observed between the Iberomauresian Maghrebian groups and the region's later inhabitants strongly suggests the Neolithic transition was accompanied by profound genetic changes; thus strongly confuting hypotheses envisaging a spread of the Neolithic way of life through solely cultural transmission. The similarities found between all of the Mediterranean Holocene groups and the earlier Natufian one, moreover, supports a Near/Middle Eastern origin for such gene flux.

The considerable dissimilarity observed between the Holocene Maghrebian group and both the coeval Saharan and Spanish ones seem to confute hypotheses envisaging the transmission, to such region, from either Spain or the Sahara. On the contrary, the results obtained seem to suggest a spread of the Neolithic, from the Near/Middle East, through two or more routes; one along the northern and a second along the southern shore of the Mediterranean basin. They, moreover, indicate the gene flux along the southern shore of the Mediterranean must have followed, necessarily, the Maghrebian corridor; leaving out of its path the confining, more southern populations inhabiting the Sahara.

The proximity of the Neolithic group from Kenya to the Mediterranean Neolithic ones, seems to suggest the presence of at least a third route that descended along the Nile and, from there, to Kenya.

## CONCLUSION

The results, indeed, seem to strongly support the demic diffusion model, suggesting the transition to a Neolithic subsistence was accompanied by consistent population replacement. They, moreover, suggest that the Neolithic revolution spread in different directions and, in particular, they seem to indicate routes along the northern and southern coasts of the Mediterranean and towards the Arabian Peninsula and Kenya.

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## **ADVANCED INVESTIGATIVE TECHNIQUES FOR THE RECONSTRUCTION OF INDIVIDUAL LIFE HISTORY IN PAST HUMAN POPULATIONS.**

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The reconstruction of the individual life history from the odontoskeletal remains of past human populations represents one of the most challenging and promising tasks in paleoanthropology. Hominins, like all living organisms, pass through major life stages; life history reconstruction seeks to explain cross-species and cross-populations differences in the timing and covariation of these stages. Traits such as age at weaning, timing of dental enamel and dentine development, aspecific stress chronology estimate during childhood, changes in diet, and ultimately life span represent an invaluable record in reconstructing adaptive strategies, health conditions, migration, age- and sex-related growth and variation patterns of extinct taxa and populations.

Inferences about the life history of past populations must be extracted from fossilized remains of the hard tissues and particularly from teeth. Dental enamel and dentine in fact grow in an appositional manner and do not remodel through life. It is therefore possible to determine, within a reasonable error range, a set of important variables like deposition/maturation rates, changes in biochemical composition, and timing of stress events. During the last decade a number of analytical tools has been developed and applied to fossil and sub fossil human remains in order to estimate variables related to life history. Nevertheless, the task of using this record to document past population and help understand these complexities has barely begun. Moreover, because of taphonomic dynamics and diagenetic events, signals from this record are often noisy. Last but not least, some aspects of the intimate ontogenetic trajectories of dental tissues, like the time and mode of enamel mineralization, are still poorly understood and require further investigation. We present some advanced investigative tools and results contribution to the analysis of individual life history related traits from fossil and sub fossil human teeth and bones. The combined use of histological methods and compositional/isotopic LA-ICPMS profiles in human tooth enamel allows in fact a deeper understanding of enamel maturation phases and provides a standard for the interpretation of feeding practices during childhood; the use of MR high resolution imaging of fossil and extant humans teeth shows the potentiality of a still underused analytical tool for the analysis and quantification of dentine growth patterns.

The management/fruition of the anthropological heritage requests awareness of the importance of such kind of research tools, which are proven to be of great efficiency even if some concerns about preservation could rise. The development of non invasive tools as MR high resolution imaging or surface LA-ICPMS represents an important technological advancement still to be fully appreciated and exploited.

## THE PALAEOOLITHIC SITE OF ISERNIA LA PINETA: FROM RESEARCH TO DISSEMINATION.

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Anthropic sites and their archaeosurfaces represent an unicum in the ambit of scientific research and dissemination; thus, an integrated approach is necessary in order to enhance both naturalistic and behavioural aspects. Moreover, the interventions of exploitation have to come up to the growing requirement of knowledge and utilization of information, allowing their dissemination in order to approach the world of scientists to the public that exploits the cultural heritage.

The need of a broadest intervention of exploitation, that takes into account our history and its many aspects, has brought about the achievement of many activities that have jointly contributed to carry out the scientific research, the safeguard, the exploitation and fruition of Isernia La Pineta site.

This example of intervention, tested at Isernia, joins together the strictly scientific aspects to the exploitation, safeguard and fruition demands; in fact, the public can be interactively involved in the phases of excavation, recovery, analysis and interpretation of data, thanks to the application of informatic technologies in order to take part in the methodological process. This example points out how the development of research can be integrated in the context of progress and sustainable growth.

## THE POPULATION OF ANCIENT ROME: THE LIVING CONDITIONS FROM BIOLOGICAL EVIDENCE

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During the last ten years, the intense and systematic excavation of funerary sites carried out by the Soprintendenza Speciale per i Beni Archeologici di Roma in performing its mission of control and protection of territory, has allowed the investigation of more than 6000 burials of the Roman imperial period and the collection of a considerable quantity of bio-archaeological data associated with the ancient inhabitants of the Urbs. According to historians, during the Empire the city of Rome reached an estimated population of about one million in the Augustan period. Emergency archeological excavations, undertaken when sites are directly endangered by public or private construction, allow us to attempt to reconstruct the past life of Rome. This work is focused on research and interpretation of the variability among the larger cemeteries of the suburbs of Rome from the I to the III century AD, and is part of a wider project that aims to reconstruct the environmental conditions, the health and ways of life of ancient Romans. The five topographically scattered cemeteries are Collatina, the largest excavated urban cemetery to date, Osteria del Curato, Casal Bertone, Via Padre Semeria and Castel Malnome: each site is characterized by a specific profile related to its own population, and together they can show us a picture of Rome in the Imperial period. The field-work consisted of the determination of skeletal elements, their relationship with the other components of the tomb and a preliminary estimation of sex and age at death is made. Laboratory data include metric and non metric traits of the bones and teeth; paleopathological analyses integrated with radiographic scans and analysis of non specific stress markers. The importance of the biological heritage of ancient people is clear and it cannot be ignored or studied in an arbitrary manner, as it was at the beginning of the last century and, unfortunately, still sometimes happens: the recording of bio-archaeological data in the field and the subsequent laboratory study of the osteo-dental finds represents a unique and necessary tool to understanding the life of our ancestors.

## NEOLITHIC TRANSITION IN SOUTHERN ITALY: AN ISOTOPIC APPROACH

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Neolithic transition was one of the most important events in human history: Europe as a whole was profoundly affected by demographic, socio-economic and cultural changes which led to the birth of agricultural and breeding systems. Many questions related to Neolithic transition are largely debated and yet without answers; first of all, the one that regards in which way agriculture spread (diffusion of people or ideas?). The study aims to resolve this issue through stable isotope analyses in order to evaluate dietary habits and mobility of early farmers in Southern Italy and economic change associated with the arrival of agriculture. We reported preliminary isotopic results from human and faunal remains excavated from Neolithic sites of Apulia, Latium and Basilicata and pre-agricultural sites of Calabria and Sicily. The application of chemical-physical surveys, such as isotopic analyses, to ancient samples can provide a valuable molecular approach to anthropological studies.

## PEOPLING OF EASTERN ADRIATIC - CONTINUITY OR REPLACEMENT REVEALED THROUGH GENETIC HERITAGE

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Numerous anthropological studies of modern European populations indicated pronounced diversity between and among various groups confirming the complexity of interactions between components of the "eternal triangle" (heredity, environment and culture). Occasionally, a connection has been established between the frequency of individual systems and borders of language families as well as phylogeographic distributions of different polymorphisms, although many questions remain unanswered.

For several decades holistic anthropological research has been conducted in the Eastern Adriatic region as well. Detailed characterization of historical events, population movements and migrations, demographic peculiarities, family structure, linguistic peculiarities, and various biological and genetic traits were investigated revealing possible routes of the peopling of this Mediterranean area. Within the context of this research, this paper will address various scenarios of (micro)evolution in this area, through the analysis of mitochondrial and DNA Y chromosome lineages of the modern populations of South-Eastern Europe as a detailed model for the generation of new hypotheses. This analysis indicates that certain explicit hypotheses, not necessarily dependent, can rightfully be posed with regard to the potential connection between historical origin, migration and mobility patterns of men and women from the current localization of individual population groups with the frequency forms of their (individual) genetic lineages.

An overview of the possible interpretations of prehistoric and historical scenarios will be provided including factors such as: population exchange, demic diffusion, short-term and long-term migration movements and mobility of the populations, the assessment of possible founder individuals, the form of selection of reproductive partners, the effect of possible settling and population reflux and the dependence of demographic characteristics of various historical groups. The current findings of mitochondrial and DNA Y chromosome lineages of the population of SE Europe will be analysed and interpreted with an emphasis on the fact that historical processes are the laboratory in which modern human populations were formed and that the Eastern Adriatic and western Balkan can be considered as a reservoir and a starting point of I1b-P37 post-glacial dispersal in human populations.



## PLANTS IN THE ANCIENT ARTISTIC REPRESENTATIONS AS A TOOL OF COMMUNICATION AND A CULTURAL MESSAGE

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### Abstract

By several elements of the ancient art, it is possible to notice the perception of nature that man used to have and the deep meaning of choices seemingly only aesthetic. This appears more evident observing buildings which were linked to worship or, more generally, to the transcendental world. The representation, more and more stylized, of phytomorphic elements needs to be correlated with the “meaning” of what was depicted, as it could be noticed on Egyptian capitals, where more formerly palms (*Phoenix dactylifera*), loti (*Nymphaea caerulea* e *N. lotus*), papyri (*Cyperus papyrus*) recur while, in the Greek-roman world, bear’s breeches (*Acanthus mollis*) and lilies (*Lilium candidum*) occur, all with a highly defined symbolic meaning. This can be observed also on funeral furnishings, where poppy capsules and their stigmatic disk or other prosperity and fertility auspicious elements (*Araceae* inflorescences, *Punica granatum* fruits etc.) are frequent and which are utilised in architectonic moulding too. In some relevant cases, due to the purchaser’s importance and the involvement of top ranking personalities of the scientific and artistic spheres of that times (e.g. *Livia’s villa* and *Ara Pacis Augustae*), these representations became the tool of a real language, probably as the only way of communication with illiterate, though still capable to appreciate Nature’s “signs”, people. Such a meaning has gone weaker over time, mined also by ideological-religious reasons, which led man to the centre of the universe, and nowadays is almost dissolved. By means of systematic analysis both of the artistic representations and of the monumental works, it is possible to trace the evolution of the plants-culture binomial, with the objective of recover those values which are themselves the roots of every civilization.

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**Keywords:** plants culture, archaeology, symbolic representation, Livia’s Villa, Ara Pacis

### 1. INTRODUCTION

Plant representation in paintings and sculptures comes from remote epochs. Often in archaeological remains and monuments, nature, realistically represented or simply stylized, seems to assume a great iconographic importance.

We introduced, therefore, the term “phytoiconology” in order to characterise the field of study which analyses vegetal representations to obtain other related information [1]. This approach shows a great relevance to complete the interpretative outline of a monument, and to improve information about history and diffusion of plant species, or about evolution of cultivated ones.

By several elements of the ancient art, it is possible to notice the perception that man used to have of nature and the deep meaning of choices seemingly only aesthetic. In the ancient art, the use of the symbols was omnipresent, and it was a way of expression and communication.

In the Mediterranean basin and West Asia, we observe a common use of symbolic signification of vegetal elements. This is due to the relative influence of Egyptian, Sumerian, Babylonian, Etruscan and Roman-Greek cultures [2-5].

In order to understand the real meaning of these symbolic significations, it is necessary to trace back also their origins in the culture, religion and mythology of these ancient cultures.

The representation of phytomorphic elements needs to be correlated with the “meaning” of what was depicted.

This could be noticed on Egyptian capitals, where more formerly palms (*Phoenix dactylifera*), tree of life par excellence and regeneration symbol in this culture, loti (*Nymphaea caerulea* e *N. lotus*) and papyri (*Cyperus papyrus*) recur as symbols of Upper and Lower Egypt.

In the Greek-roman world, bear’s breeches (*Acanthus mollis*) and lilies (*Lilium candidum*) similarly occur, the first one as a symbol of rebirth, renewal, renovation and the second as a symbol of purity and related to the goddess Era-Juno.

The use of plant for symbolic meaning can be observed also on funeral furnishings, where poppy (*Papaver somniferum*) capsules and their stigmatic disk or other prosperity and fertility auspicious elements (*Araceae* inflorescences, *Punica granatum* fruits etc.) are frequent and utilised in architectonic moulding (e.g. balustrades) too.

The aim of this contribution is to give some relevant example, coming from the Roman culture, of this way of communication and to stimulate further researches in this field.

## 2. CASES OF STUDY IN ROMAN ARCHAEOLOGY

### 2.1 Livia's Villa at Prima Porta

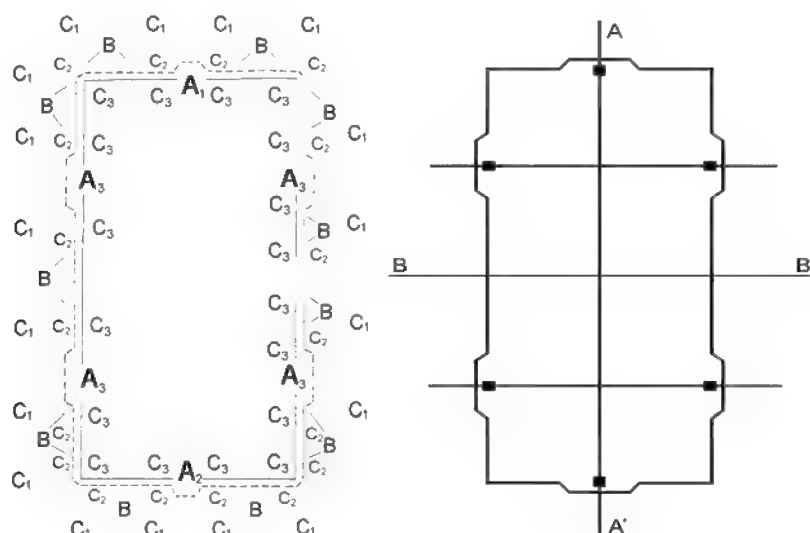
The frescoes of Livia's Villa at Prima Porta (Rome) are one of the most famous representations of Roman gardens [6]. They have been often erroneously interpreted as a kind of *trompe l'œil*, with a mere ornamental function but, on the contrary, as some authors have already pointed out [7-10], after a thorough analysis they show a clear sacred and symbolic purpose.

The twenty-four species represented belong to the spontaneous elements growing in the Mediterranean forest and maquis surrounding Rome, such as *Arbutus unedo*, *Laurus nobilis*, *Nerium oleander*, *Quercus ilex*, *Quercus robur* gr., *Cornus mas*, *Phyllitis scolopendrium*; or widely cultivated, such as *Cupressus sempervirens*, *Cydonia oblonga*, *Pinus pinea*, *Punica granatum*, *Rosa centifolia*, *Phoenix dactylifera*. The picture describes an environment drawn up following a clear ordering thought, and it shows only some analogies with a classical Pompeian garden or with a natural environment. Among the differences, it has to be considered the setting in an emblematic place (cave and hypogeum), which recalls the passage from man's world to heaven. Moreover, looking at the arrangements and the dominant elements of the iconographic scheme, firstly the contrast and the duality of the binomial pine/oak arises (that corresponds to the goddess Cybele-Hera/Jupiter-Zeus); these plants are the sole elements represented only one time and in a central position on the short sides. Alongside them, a third main element (spruce fir) emerges –forming a tetrad on opposing sides – and it represents, due to its meaning in the Roman culture, a clear funeral valence («*feralis arbor et funebri indicio*»).

Equally evident is the continuous succession of pomegranate and quince tree. The first is linked not only to the cult of the Great Mother but also of the moon goddess Kore-Persephone, besides Dionysus and Aphrodite. Pomegranate tree, in fact, was the tree that Aphrodite planted in Cyprus and this fact strengthens, together with the connection to Demeter, the fertility symbolism but also, and most of all in this case, of regeneration. Quince tree, particularly its fruits, was used in the Greek tradition, as an auspicious and protection from bad influences valence. These fruits were consecrated to Aphrodite and Hera and were considered as an emblem of love and happiness, but they represented also the *mala aurea* of the Hesperides' garden. This was an emblematic place located where the world ends and the golden fruits growing there represent the hope for immortality and for the overcoming of each own limits. In the background and along the walk, elements which refer to death (chrysanthemum, oleander, opium poppies, cypresses, holm-oaks, violets, hart's tongues) are mixed to those referring to immortality, regeneration, and love and fertility (palms, laurels, roses, myrtles).

In conclusion, the whole iconographic scheme could seem the representation of an ideal garden in which the spiritual and religious element clearly dominates and that leads to consider human life as temporary but still eternally capable of renewal and regeneration. The symbolism appears then overall connected to a philosophic vision of the life in which death is not considered as final, but only a transition waiting for a rebirth.





**Fig. 1** - Livia's villa and the hierarchic way of image composition [7].

## 2.2 Ara Pacis Augustae

The Ara Pacis is one of the most important Roman monuments, projected to celebrate the Augustus's return from expedition in Gaul and Spain (happened the 13 BC, four years before the inauguration), with a wish for a new peaceful age. The iconographic project of the monument had to underline the new values of the Augustus power and a senatorial commission approved the choice of subjects represented on the monument [11].

As for the Livia's villa, the vegetable scheme which decorate most of the marble relieves doesn't appear as a simple ornamental motif but, looking at the whole of it and at the details of its elements, results instead worthy of a more careful consideration.

As it could be observed considering several elements linked to the Hellenistic and then Christian culture, the central component of all of the six panels, is a big bush of bear's breech from which branches with sinuous spirals develop, these not strictly relevant with the generator element. The generator element, symbolizing immortality has always a basal and central position, and from time to time other elements join it giving the impression of a fanciful and little real nature which should be thought of under a more critical and considered point of view. The fanciful and «unreal» elements result, in fact, from the simultaneous and «impossible» composition of real elements. Giving this, it is important to resolve nature in elementary pieces and subsequently reassemble it, after the interpretation of the sequence meaning. It appears to be fundamental the sense of a continuous regeneration of an element from another one and the final spiral, which actually produces always new elements, appears to indicate the lack of an end. The general meaning seems to be the representation of Nature in its continuous regeneration, as appears clear in the spring stages of its awakening.

Why are plants, with their stems, leaves, flowers and fruits, the dominating element of this work? This may be answered by acknowledging the fact that macroscopically, as well as for the men of antiquity, the vegetal element is the one that best expresses the idea of rebirth. This belief is reflected in the mythology of antiquity, starting from the Mysteries of Eleusi and the narration of the divine birth of wheat as well as in the description of the figure of Dionysius, God of lymph, the 'blood' of plants that gives birth to trees each spring. Similarly, we must also mention the oriental figures of the Great Mother Cybele and Attis, of Phrygian origin, as well as Adonis, from Syria, that would have been well known to Romans. Finally, the Egyptian cult of Isis and Osiris sheds light on the natural cycles of death and rebirth, and again these cannot be neglected in the context of roman antiquity [12].

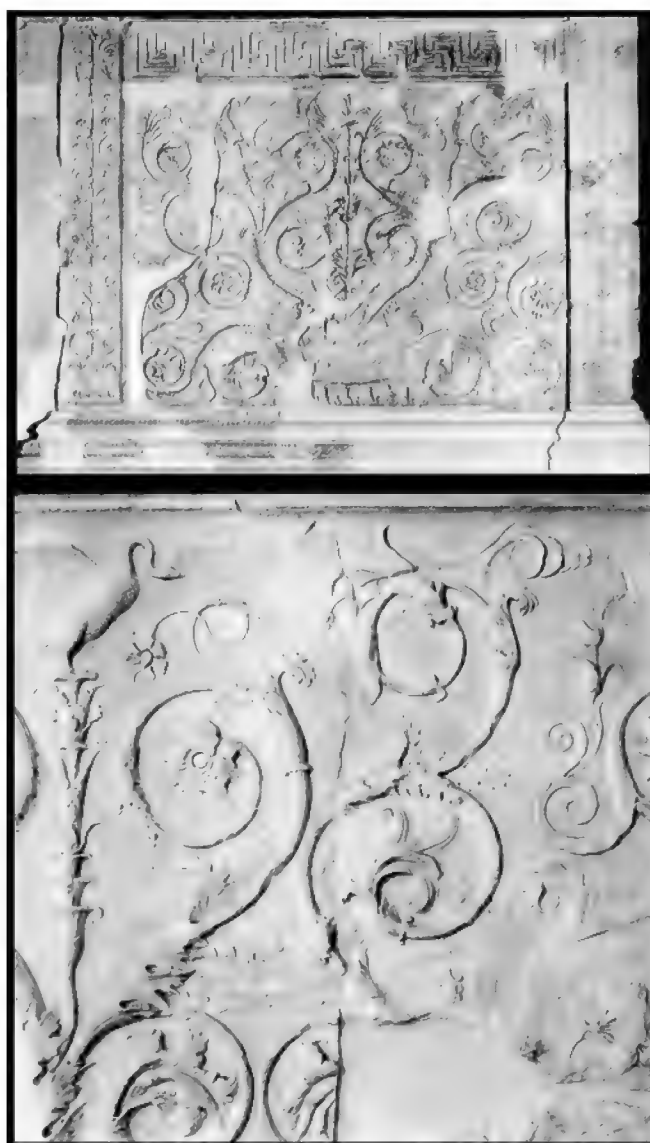
Thus vegetal structures appear to be most suitable to represent the effects of peace, as in springtime after the winter, or after summer draught, or also after traumatic events, such as wartime devastation, and surely the blooming of flowers can be interpreted allegorically to depict this. Rebirth, that is possible thanks to peace and unity in multiplicity, is therefore going to be intended as the requirement for a new prosperity, a prelude of *Augustus's aurea aetas*. It is expressed in the development of arid environments, where cardoons and thorny plants prevail, into the final 'explosion of flowers' and the enormous blossoming represents the augur of a happy era.

The role of the generative element (*Acanthus*), giving rise to a beautiful model of symmetry and of numerical composition that leads to the idea of beauty and harmony, seems here to represent Rome and the propagation of its model of order arising from this colonial structure seems to suggest the perspective of the Roman Empire foundation.

The synchronous fusion of different elements, more than been referred to a fantastic concept, could ideally underline

the continuity relationship between one species and another, as exists in Nature.

Finally the meaning of a representation in which appears the negation of an end, the absence of a limit, signifies a projection towards eternity. It also seems to allude that the process of birth and growth of the Roman Empire that has begun will be victorious and will have no end. Looking at the relationships between upper parts and lower ones, the role of Augustus and of its family, is clearly underlined. It is possible to view the position of the swans (Apollonian and Augustan symbols) on the upper part of the vegetal panels as a symbol of the superiority of Augustus' model, or at least as the symbol of its success [13,16].



**Fig. 2** - Details from the Ara Pacis' phytomorphic parament.

### **3. CONCLUSIONS**

This analysis whish to underline the need of deeper interpretation of many other “naturalistic representation” coming back to a loosen way of communication in which Nature was used to bring fundamental messages, through a well known and consolidated symbolic language. The meaning and the use of this tool has gone however weaker over time, mined also by ideological-religious reasons, which led man to the centre of the universe, and nowadays it is almost dissolved.

By means of systematic analysis of Nature occurring both in the artistic representations and in monuments, it is possible to trace the evolution of a plants-culture binomial, with the objective of recover those values which are themselves the roots of every civilization.

We hope that a wide project of research focussed on this aims, involving the whole Euro Mediterranean area will give a substantial contribution on the knowledge of common or different roots of our civilization.



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# PLANT LISTINGS FOR THE HISTORIC GARDENS OF EASTERN SICILY

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## Abstract

In recent years increasing attention has been paid to the role of historic gardens in relation to their validity as examples of cultural heritage as described by ICOMOS (International Council of Monuments and Sites) in the Charter of Florence of 1982.

In recent years, many studies have been carried out on the historic garden flora considered as unusual botanical compositions. This is particularly true for the historic gardens of Sicily, built between the late 19<sup>th</sup> century and early 20<sup>th</sup> century when acclimatization gardens were in vogue. The complex history of Sicily, with its centrally strategic position in the Mediterranean made it an important crossroads of civilization, and also influenced the use of ornamental plants in historic gardens. However, very few studies have been carried out on these typically small gardens.

With the aim of creating plant listings to help with historic garden maintenance and conservation, some years ago research was started to analyse the species in Eastern Sicily's historic gardens. In particular 45 gardens, of private ownership, were analysed, most of them are realised from the late 17<sup>th</sup> and early 20<sup>th</sup> century. The results show that these gardens were characterized by great plant diversity, despite their small surface area. The taxa of ornamental plants identified were 487 belonging to 329 genera and 123 botanical families. Identifying the floral components and lists of indicator plants has allowed us to classify the species clusters which typify the gardens in relation to their geographic area, urban or suburban site, their age and altitudinal.

The acquired data is then set up as a fundamental instrument for a global understanding of vegetal heritage of the historic gardens of Eastern Sicily, a heritage of significant scientific value and an expression of the cultural, historical, economic and social context of the areas in which these gardens were created. An evermore ample knowledge of the vegetal heritage of these cultural legacies constitutes, in our opinion, the premises for their safeguard, development and any restorative intervention.

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**Keywords:** biodiversity, ornamental plants, plant characteristics, garden conservation, garden restoration

## 1. Introduction

The Florence Charter of 1982 is the main reference for historic garden studies. In article 2 of this charter it states that “the historic garden is an architectural composition whose constituents are primarily vegetal” and, in article 6, it defines ‘historic garden’ as equally applicable to small gardens and large parks, whether formal or landscaped. Furthermore, article 12 highlights the need for maintenance, conservation, restoration and reconstruction of historic gardens to be able to define the botanical species at their outset: “*Those species of trees, shrubs, plants and flowers to be replaced periodically must be selected with regard for established and recognized practice in each botanical and horticultural region, and with the aim to determine the species initially grown and to preserve them*”. This is the main objective of our research which aims to compile plant listings which characterise the historic gardens in Sicily.

Parks and gardens represent living and dynamic components in which change happens slowly, dramatically or unexpectedly [1]. The main causes of their deterioration are due to the lack of or insufficient maintenance, above all regarding the plants which need, far more than any other garden component, constant care. Another source of deterioration, may be a change in use of the garden or mistaken restorative interventions. A third issue is the change in ownership of the gardens; new owners may contribute to good conservation or restoration just as they may cause irreversible alterations [1].

Since most garden deterioration is linked principally to plants it is worthwhile highlighting that knowledge of the original botanical choices may facilitate their possible substitution. However, this data is not always easily obtainable especially if the number of potentially applicable species is high. This is what happens in the Mediterranean region where, because of the mild winter temperatures, especially along the Southern coast of Italy and around Sicily, the use of tropical and subtropical species are promoted. Conversely, the problems associated with dry summer have been historically overcome through the practice of irrigation.

Usually, private garden florules are among the most diversified compared to other types of green space, especially those of historic interest. “The proportion of exotic plants is often very high [2], probably because the garden plants are rarely viewed from an ecological perspective”. The garden owner's desire to have a collection of unusual plants with resplendent flowers and special habitats has traditionally oriented him towards exotic species.

Due to its strategic location in the center of the Mediterranean basin, Sicily has had great opportunities to import plants from other countries and has a significant number of plant nurseries like the 'Giardino Allegra', which

has operated since the first half of the 20<sup>th</sup> century [3], which resulted in historic gardens with particularly rich plant vascular flora [4, 5].

Few studies have been carried out in Eastern Sicily to identify and characterise historic gardens which represent an important cultural legacy. The fragmentary nature of knowledge about them is probably due to these green spaces being almost entirely private property and having limited surface areas. Notwithstanding, these gardens conserve high biodiversity making it one of their characteristics.

So, the main objective of the research was to ascertain by frequency the floral components of the historic gardens in the provinces of Catania, Ragusa and Messina and to create a listing of the plants utilisable for maintaining, conserving and restoring these gardens.

	Groups of gardens		Taxa (n.)	Genera (n.)	Families (n.)	RS <sup>(1)</sup> media (%)	Native plants (%)	Evergreen plants (%)	Utilitarian plants (%)	Scented plants (%)	Organ of ornamental interest (%)		
											Leaf	Flower	Fruit
<b>Global biodiversity</b>			<b>487</b>	<b>329</b>	<b>124</b>	<b>11</b>	<b>13,55</b>	<b>70,02</b>	<b>11,29</b>	<b>11,91</b>	<b>48</b>	<b>44</b>	<b>8</b>
<b>Geographic area</b>	Provinces of Catania	Catania	244	187	81	17,81	12,13	74,58	11,9	13,1	52,0	41,8	6,2
		Etna village	392	271	112	18,13	17,26	68,81	13,0	12,2	49,2	41,8	9,0
	Provinces of Ragusa	Ragusa	114	90	54	26,32	20,53	78,95	14,9	14,0	57,9	36,8	5,3
	Provinces of Messina	Milazzo	140	120	73	34,64	10,14	73,13	18,6	15,7	40,0	50,7	9,3
<b>Location</b>	Urban		266	200	85	14,52	13,46	73,66	12,4	13,5	50,8	42,9	6,3
	Suburban (extra)		434	296	120	14,93	14,28	69,64	12,4	12,2	48,1	43,1	8,8
<b>Altitude classes in a.s.l.</b>	I = 0-200		293	222	94	15,20	11,84	73,33	12,3	13,0	47,8	45,7	6,5
	II = >200-400		392	268	112	18,13	15,30	68,99	13	12,2	49,2	41,8	9,0
	III = >400		114	90	54	26,32	20,53	78,94	14,9	14,0	57,9	36,8	5,3
<b>Construction period</b>	XVII-XVIII		228	174	86	24,69	17,11	73,18	14,5	14,9	47,8	43,0	9,2
	XIX		311	221	96	14,60	13,62	72,07	13,5	11,6	55,3	36,0	8,7
	XX		374	265	107	15,79	14,56	71,62	13,4	13,9	45,5	46,2	8,3

**Table I.** Main characteristics of the gardens in relation to different groups. (<sup>1</sup>SR =  $n/N \cdot 100$ , where  $n$  is the number of plant taxa for each garden and  $N$  is the total number of surveyed taxa in all the gardens analyzed)

## 2. Methodology

For some years, research has been ongoing to botanically characterise 45 gardens in Eastern Sicily. The gardens were selected by age (prior to WWII) from the homes of the well-to-do and are situated in the provinces of Catania, Ragusa and Messina. Of these, 15 are in urban Catania, 18 in the Etna village, 4 at Milazzo, 3 at Modica and 5 in Ragusa, all of them dating from the 18<sup>th</sup> century to the 20<sup>th</sup>.

The gardens have been inspected on numerous occasions in different seasons to provide the morphological characteristics necessary for identifying the plants taxonomically. Among the species surveyed there were also a number of dried plants which have been deposited with the Herbarium of the Vegetal Biology and Ecology Section of the University of Catania. European and Italian reference texts [6, 7, 8] were used to identify them taxonomically as well as other ornamental plant texts [9, 10, 11] and references to the living collections of the botanical gardens of the Universities of Catania, Palermo and Napoli.

Geographic area	CT	EV	ME	RG
Numbers of gardens	15	18	4	8
Species				
<i>Phoenix canariensis</i> Hort.ex Chaub.	IV	V	III	IV
<i>Asparagus plumosus</i> Baker	IV	IV	III	
<i>Nerium oleander</i> L.	IV	IV	III	II
<i>Portulacaria afra</i> (L.) Jacq.	IV	III	III	I
<i>Hibiscus rosa-sinensis</i> L.	IV	II	IV	I
<i>Strelitzia reginae</i> Banks	III	IV	V	
<i>Pittosporum tobira</i> (Thunb.) Ait. f.	II	V	III	II
<i>Citrus sinensis</i> (L.) Osbeck	I	IV	II	
<i>Lantana camara</i> L.	III	IV	III	I
<i>Magnolia grandiflora</i> L.	II	IV	II	I
<i>Schinus molle</i> L.	II	IV	III	I
<i>Viburnum tinus</i> L.	II	IV	II	I
<i>Laurus nobilis</i> L.	II	V	III	IV
<i>Buxus sempervirens</i> L.	I	IV	II	IV
<i>Citrus limon</i> (L.) Burm.	III	IV	III	V
<i>Hedera helix</i> L.	III	IV	III	V
<i>Citrus aurantium</i> L.		I		IV
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	II	III	II	IV
<i>Jasminum officinale</i> L.	III	II	II	IV
<i>Lavandula angustifolia</i> Mill.		II	III	IV
<i>Rosmarinus officinalis</i> L.	I	II	II	IV
<i>Wisteria sinensis</i> Sweet	II	III	III	IV
<i>Zantedeschia aethiopica</i> (L.) Spreng.	III	III	III	IV
<i>Cycas revoluta</i> Thunb.	II	III	V	V
<i>Olea europaea</i> L. var. <i>europaea</i>	I	II	IV	IV
<i>Agapanthus africanus</i> (L.) Hoffm.	I	II	IV	
<i>Bougainvillea</i> Comm. ex Juss. spp.	I		V	III
<i>Chlorophytum comosum</i> (Thunb.) Jacques	III	III	IV	
<i>Euonymus japonicus</i> L. fil.	I	III	IV	II
<i>Hydrangea macrophylla</i> (Thunb.) Ser.		III	IV	
<i>Livistona chinensis</i> (Jacq.) R. Br. ex Mart.	III	I	V	II
<i>Pinus pinea</i> L.			IV	II
<i>Plumbago auriculata</i> Lam.	II	III	IV	I
<i>Rosa</i> L. sp.	I	I	IV	III
<i>Ruscus hypoglossum</i> L.	III	II	IV	I
<i>Washingtonia filifera</i> (Linden ex André) H. Wendl.	II	III	IV	II

**Table II.** Synoptic table. Specific combination of plants for the groups of gardens in relation to geographic area. For nomenclature, reference was made to the 'International Plant Names Index' [12] and the USDA, ARS and the National Genetic Resources Program - Germplasm Resources Information Network - (GRIN) [13].

To process the data more functionally, a database containing the following was set up: scientific name, botanical family, origin [9], habitat (herbaceous, geophyte, shrub, tree, palm, palm-like, climber, aquatic and succulent), date of introduction into Italy [14], pedo-climatic needs [15], climatic zone [16], ornamental component of main interest (leaf, flower or fruit), and possible utilitarian or fragrance use (flowers or leaves). The database



helped us manage the information pertaining to every single garden which were homogenously grouped by: construction period (17-18<sup>th</sup>, 19<sup>th</sup> and 20<sup>th</sup> centuries), geographic area [Catania (CT), Etna villages (EV), Messina (ME) and Ragusa (RG)], location (urban or suburban) and altitude (3 classes: I = 0-200; II = >200-400; III = >400m a.s.l.).

For all the gardens and for each homogenous group of gardens, plant data was expressed as % frequency and this determined which of five classes they were allocated to: I =  $\leq 20$ , II = >20-40, III = >40-60, IV = >60-80, V = >80%.

To compare the different garden categories, synoptic tables of species with a >60% frequency (classes IV and V) were created. Furthermore, for each homogenous garden group, an average number of species was identified and for each single garden species richness (SR) was calculated according to the following formula:  $SR = n/N \cdot 100$ , where n is the number of plant taxa for each garden and N is the total number of surveyed taxa in all the gardens studied. The biodiversity, for each group of gardens, was summarised by the average value of species richness.

Garden location	UR	SU
Numbers of gardens	21	24
Species		
<i>Jasminum officinale</i> L.	IV	II
<i>Hedera helix</i> L.	IV	IV
<i>Phoenix canariensis</i> Hort.ex Chaub.	IV	V
<i>Buxus sempervirens</i> L.	II	IV
<i>Citrus limon</i> (L.) Burm.	III	IV
<i>Cycas revoluta</i> Thunb.	III	IV
<i>Lantana camara</i> L.	II	IV
<i>Laurus nobilis</i> L.	III	IV
<i>Nerium oleander</i> L.	III	IV
<i>Pittosporum tobira</i> (Thunb.) Ait. f.	II	IV
<i>Strelitzia reginae</i> Banks	II	IV

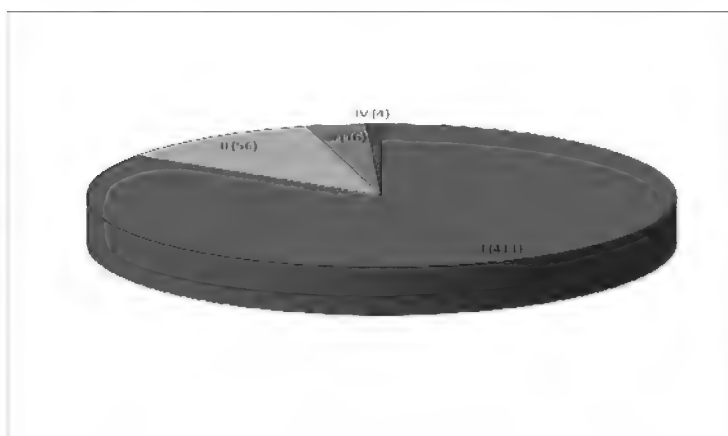
**Table III.** Synoptic table. Specific combination of plants for the groups of gardens in relation to garden location (UR= urban, SU= suburban)

### 3. Results and Discussion

#### 3.1. General characteristics of Sicilian garden plants

The flora census identified, in the 45 gardens of Eastern Sicily, 487 taxa belonging to the 329 genera of 123 botanical families. The most common families were: *Rosaceae* (15 genera and 28 species), *Asteraceae* (16 genera and 17 species), *Fabaceae* (12 genera and 19 species), *Arecaceae* (13 genera and 21 species), *Cactaceae* (10 genera and 15 species), *Oleaceae* (6 genera and 15 species).

Figure 1 shows how many of the census plants are present in a few gardens: 84% of taxa (411 botanical entities) have a frequency lower than 20 percent (class I), 11% (56 botanical entities) between 20 and 40% (class II), 3% (16 taxa) between 40 and 60% (class III) and only 4 botanical entities show a frequency over 60% (class IV) (*Nerium oleander* L., *Laurus nobilis* L., *Hedera helix* L. and *Phoenix canariensis* hort ex Chaub.). No taxa were found in class V (presence in over 80% of the gardens).



**Figure 1.** Taxa percentages according to their frequency class. In brackets are the number of species in absolute values according to frequency class. No taxa were found in class V (frequency > 80%). (I = ≤ 20, II = >20-40, III = >40-60, IV = >60-80, V = >80%)

As regards the geographic origin of the taxa, the majority of plants are exotic (data not shown). As highlighted in other scientific work [17], this agrees with that found in other historic parks and gardens in Sicily ever since the 19<sup>th</sup> century. They have suffered greatly from the fashion of acclimatization gardens, in vogue in this period [18, 17], which significantly promoted the use of exotic plants to the detriment of native plants. Among the exotic plants, a significant role is played by the palms (*Phoenix* spp., *Washingtonia* spp., *Livistona* spp., *Brahea armata* S. Watson, *Howea forsteriana* Becc.) and climbing plants (*Jasminum* spp. and different species of *Bignoniaceae* family).

The historic gardens of Eastern Sicily are generally characterised by fragrant plants, being 11.9% of the total. That they are widespread may be a result of Arab civilisation [19]. Even the utilitarian plants at 11.3% represent the strong link between ornamental function and the practical garden [3]. Among the most common species are: *Citrus* sp. pl., *Cydonia oblonga* Mill., *Diospyros kaki* L., *Eriobotrya japonica* (Thunb.) Lindl., *Ficus carica* L., *Olea europaea* L. var. *europaea*, *Opuntia ficus-indica* (L.) Miller, *Prunus persica* (L.) Batsch., *Punica granatum* L. and *Vitis vinifera* L. ssp. *vinifera*.

In the study's gardens, various monumental and/or ancient trees were found as well as botanical rarities like *Ficus macrophylla* Desf ex Pers. ssp. *columnaris* (C. Moore) P.S. Greene, *Searsia lancea* (L. f.) F.A. Barkley, *Pittosporum tobira* (Thunb.) W.T. Aiton, *Haemanthus coccineus* L., *Nolina longifolia* Hemsl., *Sparmannia africana* L.f. In the gardens of the past, these plants confirm their role as biodiversity pools and places for the conservation of germoplasm [20]. It should be noted that many of the plants in the census (e.g., *Camellia japonica* L., *Hibiscus rosa-sinensis* L., *Nerium oleander* L., *Bougainvillea* spp., *Rosa* spp.) show pronounced intraspecific variability expressed by different floral morphologies and petal chromatisms.

### 3.2. Plant characteristics for various garden types

Notwithstanding the general features of historic gardens are similar, comparing different geographic areas highlights their floral and aesthetic differences. In particular, the gardens of Catania have considerable biodiversity (244 taxa of 187 genera and 81 families) with a low SR (17.8) (Table I). SR is a measure of floral diversity between gardens which singularly provide a contribution to global biodiversity where they are located: each garden is unique and therefore a cultural legacy to conserve. These gardens are also characterised by a low percentage of native species by contrast with a high level of exotics. This is probably due to the favourable climatic conditions in Catania and the ease which garden owners have been able to procure exotic plants from the considerable number of nurseries in the area as well as from the botanical gardens of the University established at the beginning of the 20<sup>th</sup> century [3]. The largely ornamental role of these gardens is underlined by the lower incidence of utilitarian plants (Table I). Furthermore, Table II shows Catania's gardens have a specific combination of plants which is distinct from those of the Etna village, Messina and Ragusa. The most frequent species are those with high thermal requirements like *Hibiscus rosa-sinensis* L., *Nerium oleander* L., *Phoenix canariensis* Hort.ex Chaub. e *Portulacaria afra* (L.) Jacq.

The Etna gardens show the highest bio-diversity: 392 taxa of 271 genera and 112 botanical families (Table I). This is probably linked to the greater surface areas devoted to ornamental plants compared with Catania. The incidence of native and utilitarian plants is higher than for Catania which underlines the closer link which these gardens create between ornamental, rural and landscape spaces. The lowest urbanisation surely favours this relation. Among the most frequent species are *Buxus sempervirens* L., *Hedera helix* L., *Laurus nobilis* L., *Magnolia grandiflora* L., *Pittosporum tobira* (Thunb.) Ait. f., *Viburnum tinus* L., which surely take advantage of the higher humidity (Table II).

In the gardens of Ragusa, biodiversity is lower (114 taxa of 90 genera and 54 families) perhaps connected to its relative isolation and distance from main ports. The most frequent species are mostly utilitarian like *Citrus* spp., *Eriobotrya japonica* (Thunb.) Lindl., *Olea europaea* L. var. *europaea*, aromatic ones like *Lavandula angustifolia* Mill. and *Rosmarinus officinalis* L., and fragrant species like *Jasminum officinale* L. and *Wisteria sinensis* Sweet. Another high frequency plant in the area is *Cycas revoluta* Thunb., some of which were over 150 years old (Table II).

Notwithstanding the modest census, the gardens of Messina show appreciable floral diversity (140 taxa of 120 genera and 73 families), a low number of native species and a significant number of utilitarian species (Table I). The vicinity of the main port of Messina, the ancient botanical traditions of the city (Hortus Messanensis was founded in 1638) [21] and a dominant aristocracy all favoured the use of exotic plants (about 90%) and strongly influenced the original composition of these gardens.

Separating the gardens into urban and suburban reveals the higher biodiversity in the suburbs probably due to the greater surface areas dedicated to ornamental plants. The urban group shows a lower percentage of native plants. A limited number of plants is common to both groups (*Asparagus plumosus* Baker, *Cycas revoluta* Thunb., *Hedera helix* L., *Laurus nobilis* L., *Nerium oleander* L., *Phoenix canariensis* Hort.ex Chaub.), but their biological profile is quite different as shown by the diverse frequency of each taxon (Table III).

The classification of gardens by age clearly indicates that plant contribution is subject to change over time (Table IV). Moreover, finding 18<sup>th</sup> century gardens with plants subsequently introduced into Italy (e.g., *Bougainvillea* spp.) testifies to the dynamism of green spaces. Another interesting component worth mentioning is the floral wealth of those gardens of more recent construction (19<sup>th</sup> – 20<sup>th</sup> century) (Table I).

Ordering the gardens according to height emphasises a progressive decrease in biological diversity as height increases. The species combination which distinguish the three height classes are in Table V.

Construction period	XVII-XVIII	XIX	XX
<b>Numbers of gardens</b>	<b>7</b>	<b>17</b>	<b>21</b>
<b>Species</b>			
<i>Cycas revoluta</i> Thunb.	V	III	III
<i>Zantedeschia aethiopica</i> (L.) Spreng.	V	III	III
<i>Citrus deliciosa</i> Ten.	IV	II	II
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	IV	II	III
<i>Citrus limon</i> (L.) Burm.	V	III	IV
<i>Hedera helix</i> L.	V	III	IV
<i>Laurus nobilis</i> L.	V	III	IV
<i>Phoenix canariensis</i> Hort.ex Chaub.	III	V	V
<i>Asparagus plumosus</i> Baker	III	II	IV
<i>Nerium oleander</i> L.	III	III	IV
<i>Portulacaria afra</i> (L.) Jacq.		III	IV
<i>Ruscus hypoglossum</i> L.	III	I	IV
<i>Strelitzia reginae</i> Banks	III	II	IV

**Table IV.** Synoptic table. Specific combination of plants for the groups of gardens in relation to construction period

Altitude classes	I	II	III
Numbers of gardens	19	18	8
Species			
<i>Phoenix canariensis</i> Hort.ex Chaub.	IV	V	IV
<i>Nerium oleander</i> L.	IV	IV	II
<i>Asparagus plumosus</i> Baker	IV	IV	
<i>Strelitzia reginae</i> Banks	IV	IV	
<i>Portulacaria afra</i> (L.) Jacq.	IV	III	I
<i>Chlorophytum comosum</i> (Thunb.) Jacques	IV	III	
<i>Hibiscus rosa-sinensis</i> L.	IV	II	I
<i>Livistona chinensis</i> (Jacq.) R. Br. ex Mart.	IV	I	II
<i>Laurus nobilis</i> L.	III	V	IV
<i>Citrus limon</i> ( L. ) Burm.	III	IV	V
<i>Hedera helix</i> L.	III	IV	V
<i>Buxus sempervirens</i> L.	I	IV	IV
<i>Pittosporum tobira</i> (Thunb.) Ait. f.	II	V	II
<i>Lantana camara</i> L.	III	IV	I
<i>Schinus molle</i> L.	III	IV	I
<i>Magnolia grandiflora</i> L.	II	IV	I
<i>Viburnum tinus</i> L.	II	IV	I
<i>Citrus sinensis</i> ( L. ) Osbeck	I	IV	
<i>Cycas revoluta</i> Thunb.	III	III	V
<i>Zantedeschia aethiopica</i> (L.) Spreng.	III	III	IV
<i>Jasminum officinale</i> L.	III	II	IV
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	II	III	IV
<i>Wisteria sinensis</i> Sweet	II	III	IV
<i>Olea europaea</i> L. var. <i>europaea</i>	II	II	IV
<i>Lavandula angustifolia</i> Mill.	I	II	IV
<i>Rosmarinus officinalis</i> L.	I	II	IV
<i>Citrus aurantium</i> L.		I	IV

**Table V.** Synoptic table. Specific combination of plants for the groups of gardens in relation to altitude classes

#### 4. Conclusions

The private historic gardens annexed to residences in Eastern Sicily show high floral diversity as well as valuable and ancient plants. So, they play an important role in conserving in situ biological diversity [22]. Even though only obtained from 45 gardens, the results highlight the most common taxa and the floral components and plant list have helped identify compositional differences linked to geographic location, whether urban or suburban, age and altitude.

The mass of data acquired in this research together with that in the literature and archived in a user-friendly and updatable database represents a fundamental instrument for a global understanding of the vegetal legacy of the historic gardens in Eastern Sicily. This legacy is of significant scientific, cultural, historical, economic and social value to the areas in which they are found [23].

The findings of this project have fired interest in extending it to other subjects within the same area as well as to other parts of Sicily.

Ever greater knowledge about vegetal legacy is to our mind the premise for safeguarding, developing and restoring cultural wealth.

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## THE ANCIENT VESUVIAN LANDSCAPE RECONSTRUCTION AND THE GARDENS POMPEII RESTORATION.

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### Abstract

Excavation techniques (archeological remains, cavities in the ground, flower beds) assisted by new methods of analysis of vegetable remains (pollens, seeds, fruits, woods) and animal remains have restored Vesuvian landscape of A.D.79 and gardens of Pompeii to their original use

Comparative analyses of iconographic imagery, written descriptions, and the finds themselves makes it possible to reconstruct the salient elements of Vesuvian landscape.

Also the gardens closed within the tall walls of ancient Pompeii constitute an extraordinary patrimony: they uniquely demonstrate the way vegetation was distributed within a city two thousand years ago.

Currently, Pompeian gardens in which it has been possible to identify the species actually cultivated in antiquity have been replanted according to their original use. Others have been left intact as evidence of outdated restoration efforts. In both cases, much attention is placed on preserving native species that have found refuge in those spaces.

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In A.D. 79 the eruption of Vesuvius “sealed” the urban orchards and gardens of ancient Pompeii. It is only in the last few years that full attention has been given to this buried treasure, and more sophisticated techniques have been used in its investigation.

Becoming familiar with the plants encountered by ancient Pompeians, with their provenance and their utilization, therefore involves acquiring information concerning the social and economic life of the Vesuvian area.

In general, plants are repeatedly referred to in Latin literature, whether scientific, poetic, or popular. Nevertheless, they are difficult to identify, because it was not until the eighteenth century that objective rules of classification were introduced by Linnaeus.

In light of the difficulties encountered in recognizing both plant and animal species described in literary sources, the naturalistic frescoes adorning Pompeian houses hold great importance for science.

In addition finds of ancient macro-and micro-remains (pollens, seeds, woods), the shapes of lawns and paths, the casts of trees and bushes and the archaeological remains that have been identified in the laboratory serve to complete and further amplify the information that iconography provides. Together, art and science furnish documentation unique for its breadth within a precisely dated historical moment.



**Fig.1** - *Medicago arabica* from ancient Pompeii

Comparative analysis of iconographic imagery, written descriptions and finds themselves makes it possible to reconstruct the salient elements of Vesuvian landscape.

In the city, the gardens closed within the tall walls of ancient Pompeii constitute an extraordinary patrimony. On the one hand, they uniquely demonstrate the way vegetation was distributed within a city two thousand years ago.

Examples of this treasure are the numerous small intensely cultivated gardens, which adjoined the houses in the less rich districts, the large urban vineyards, and the green areas used for mixed agricultural and manufacturing activities.

The city, enclosed within its walls, extends for 66 hectares (163 acres). Eleven gate and as many road axes placed Pompeii in communication with the surrounding territory . The then-navigable Sarno River permitted the city's inhabitants to enjoy commercial exchange with the interior, and the sea put them in communication with the entire Mediterranean basin.

The city rose on a spur of lava rock that overlooked an ample beach. The foliage of the tallest trees cultivated in the gardens and urban vegetable gardens rose above the rooftops, revealing the presence of large and small green space. Entering the city, one would become aware that plants were also cultivated on balconies and galleries. Sometimes the grew so thickly they give impressions of a forest, as recounted by Plinius.

The favourable climate and availability of rich environmental resources made it possible for the city's inhabitants at various levels of society to lead diverse and animated lives that included performing different arts and crafts.

About two-thirds of this city today is exposed; the northeast sector has not yet been unearthed. Excavations have revealed about 400 green areas of different dimensions distributed in a more or less heterogeneous manner. Larger spaces are concentrated in *Regiones I and II*, that is, in the southwest portion of the city. Excavation techniques, assisted by new methods of analysis, have restored these to their original use.

We do not have reliable data on the cultivation that took place in the gardens of the earliest houses brought to light. This is due to the fact that the rise of stratigraphic excavation respectful of the traces left in the ground by the plant roots was not established until the second half of the nineteenth century.

In the second half of the nineteenth century the problem of the reconstruction of garden was precisely posed by stratigraphic excavation, that, returning the shapes of lawns and paths, prompted the identification of the species depicted in the frescoes so that could then be reintroduced into the flowers beds.

In the larger *viridaria*, or interior gardens, the land was divided into flower beds that were slightly elevated above the beaten-cart paths . The flower beds were fenced by grillages of reeds or wood., thus, what appears in the iconography is confirmed.

The *viridarium* of the *House of the Chaste Lovers*, more recently brought to light, is made up of a lawn transacted by paths of flattened earth. The flower beds, fenced off by cane trellises (holes found in the earth mark their lozenge-shaped pattern) formed a complex geometrical design which lengthened the depth of field and squared off what was an asymmetrical access to the garden.

The species of plants cultivated , in the garden, which were also planted symmetrically, had both ornamental and practical uses: the grey-green leaves of the *Artemisia*, *Lychnis* and *Cerastium* contrasted with the emerald-green of the *Juniperus*. The vines masked the foundation wall and the fern plants (*Polypodium*) grew along the channels. The flowering of roses followed by *Lychnis* and *Cerastium*, ensured touches of continuous colour in the *viridarium*, but each plant also had a medicinal, seasoning or culinary purposes.



**Fig.2** - Viridarium of the House of the Chaste Lovers: reconstruction.

Irrigation was provided by rainwater collected from the roofs and conserved in underground cisterns, usually in proportion to cultivation needs. This made it necessary to set the *viridarium* at the centre of the house. With the

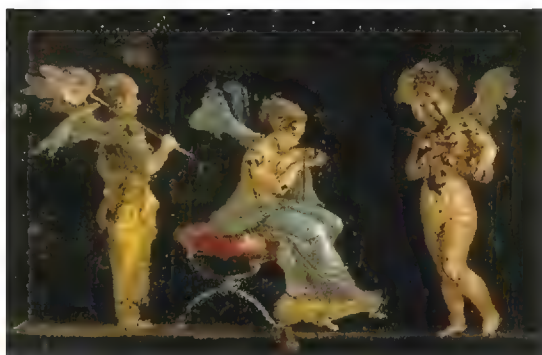
availability of running water furnished by the aqueduct, some *viridaria* could be decorated with fountains and water plays.

As in many modern cities, large sports, complexes were located on the periphery. That is where Pompeii's Amphitheater and Great Palaestra arose. That is where greater availability of space allowed the possibility of having a more extensive residence, as *Loreius Tiburtinus* and Julia Felix desired. That is where the owner of a green space could utilize it for activities other than cultivation. To again make a comparison with our cities, consider those meadows sometimes used as dumps for discarded cars.

The Amphitheater and Great Palaestra attracted many users. Large plane trees shaded this area. A famous fresco conserved in Naples, at the Museo Archeologico Nazionale, depicts those outside the colonnade of the Palaestra. The large casts still in situ provide further proof of the trees' presence. Their enormous dimensions indicate that the trees were very old, and make one think that they were positioned in the Great Palaestra because of their symbolic significance.

**The garden of *Loreius Tiburtinus*, even more than the neighbouring one of *Julia Felix*, represent the first and perhaps only example, among those excavated to date, that opens to the outside. The supply of running water provided by the aqueduct as well as the possibility of acquiring space made it possible to create a garden/park that was not enclosed within the house and therefore was of more ample dimensions.**

Along pergola flanked both sides of a euripus, or watercourse, which was decorated with statues and fountains that spanned its entire length. Massive plane trees bordering the enclosure wall towered over midsize and large fruit trees, also set out in rows. At a higher level, another pergola shaded a transverse euripus, also decorated with statues and jets of water that poured water into the lower euripus. A small flower bed contained flowering plants that excavation data suggest were set out to trace the form of a heart.



**Fig.3 - Ancient Pompeii: Forum Boarium and Amphitheater**

The garden of *Julia Felix* also had abundant water and space. In contrast to that of *Loreius*, however, this garden was composed of two sections that each seems to have lived a life of its own. In one part, a great *viridarium* was adorned with statues and fountains. In the other part, a vast fruit orchard, divided by paths, was certainly used for strolling. However, it must also have served an economic function, insofar as it provided a ready supply of fruit for the frequent visitors to the house.

The ornamental use of fruit trees also occurred in the garden of *Loreius Tiburtinus* and elsewhere in Pompeii, especially in the small green areas of *Regio I*. Studies recently undertaken on the pollens, woods, and seeds, as well as the small of cultivation found in this zone of the city, confirm this function. In particular, the discovery of a nursery that evidently furnished the city urban gardens demonstrates that small trees were cultivated and used locally. For example, hazelnut trees were prized because they produced fruits suitable for long conservation, peach trees because the value of a single peach, a fruit that perished easily, was of a single kiwi fruit in Italy twenty years ago.

In *Regio I*, therefore, excavations and laboratory research have made it possible to identify the presence of vegetable gardens, vineyards, and vast fruit orchards. The first were cultivated primarily for family use; excess produce was probably sold at market.

The cultivation of broad beans, peas, and lupins was alternated with that of cabbage, onions, garlic, and lettuce, to cite the most widespread vegetables. The great fertility of the soil made more than one harvest per year possible, and the vegetable garden was associated with a vineyard and also included some fruit trees, rendering the household virtually autonomous with respect to the most common produce.

Single vineyard could attain vast dimensions, especially considering that they were within the city. The largest of all was one in the so-called *Forum Boarium*, or Cattle Market. Another huge vineyard stretched in the same zone on the



other side of *Via di Sarno*. Not less extensive were the vineyards of *Via di Nocera* and *Via di Castricio*. All these vineyards were fitted out with equipment for winemaking such as presses, underground pottery vessels called *dolia*, in which fermentation took place, and amphorae, for the conservation of wine. Some even had wine cellars. F. 3

The distance between the vines, both in and between rows, were given by *Columella* and Pliny in their works. The varieties cultivated must have been the *Colombina purpurea* and *Vitis oleagina*, progenitors of the modern local varieties *piedirosso* and *sciascinoso*, which are currently planted *in situ* according to the ancient order of planting. Sometimes, as in the case of the vineyard of Euxinus, a bar was set directly on the street, whereas in others, as in the *Forum Boarium*, vast *triclinia* accommodated the patrons. They were designed to intercept spectators from the Amphitheater.

The extensive areas cultivated as fruit orchards were amply productive. In addition to the orchard annexed to the House of *Julia Felix*, already mentioned, other orchards were located at *Garden of the Fugitives* and the garden of the *House of the Ship Europa*. In all cases species and varieties were cultivated. Some trees produced fruits that remained unaltered for a long time, such as nuts and hazelnuts; others bore pulp fruits, such as figs, pears, peaches, apricots, plums, and eating grapes, which were consumed fresh, conserved in honey, or sun-dried.

But the extensive green spaces of *Regio I* were also destined for other uses. Products such as *garum* and matting were stored in such places, and the space could be used for agricultural and artisan productions. For example, in the large vegetable garden of the House of the Perfume Maker, fragrant plants such as irises, roses, and violets were grown. These were then steeped in the oil produced from green olives harvested from the trees in the same garden.



**Fig.4 -** Ancient Pompeii: Amorini perfumers.



**Fig.5** - Ancient Pompeii: House of the Perfume Maker

Currently, Pompeian gardens in which it has been possible to identify the species actually cultivated in antiquity have been replanted according to their original use.

Others have been left, intact as evidence of outdated restoration effort. In both case, much attention is placed on preserving native species that have found refuge in those spaces.

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## CHARACTERIZATION OF THE LICHEN FLORA GROWING ON THE SANNITIC THEATRE OF PIETRABBONDANTE (MOLISE, CENTRAL ITALY)

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**Keywords:** Archaeological area, Biodeterioration, Lichen colonization

### 1. INTRODUCTION

Archaeological areas and stoneworks often host a rich lichen colonization. They are considered an environment of particular interest [1], increasing the biodiversity of a site [2, 3, 4] and representing a refuge for a few species when the natural habitat is threatened [5]. On the other hand, lichens are the main factor in the deterioration of artworks exposed to the open air through physic-chemical processes. They are often retained also a disturbing presence because of the aesthetic damage they provoke.

This study is the initial survey of a long-term project aimed to identify the main key factors related to archaeological areas of Molise (Central Italy). The pilot project is represented by the bio-ecological characterization of the archaeological area of Pietrabbondante (province of Isernia), the most important remain of the pre-Roman Sannitic populations inhabiting the region, dating back to the IV-V century BC.

The complex was built using local hard limestone on the eastern slope of Mount Saraceno dominating the valley of Trigno River. The most important and best preserved remains of the whole area is the complex temple-theatre. It covers a total area of about half a hectare, at about 960 m. The complex is ESE oriented, so as to be aligned with the point in which the sun rises in the winter solstice.

The Theatre (Fig. 1) is located at a lower level than the main temple and is composed of two basic elements: the Càvea and the staging buildings. The main structures of the area were dug up in 1858 so that the lichen colonization can be exactly dated (150 years).

The Càvea is also characterized by a division into two parts: the lower part (*Ima Càvea*, fully preserved) consists of three rows of independent seats with an anatomical shape of the back and the upper part, the *Summa Càvea*, in which seats do not appear to have ever been built [6].



**Fig. 1.** The Theatre



## 2. MATERIALS AND METHODS

### 2.1. SAMPLING DESIGN

The survey was carried out by subdividing the Theatre in three sectors according to the main exposures (N-NE, E-SE and S-SW) and placing the releves on surfaces of three different kind of inclination on each of the three orders of seats (Fig. 2): the horizontal surfaces (seats) at almost 0°, the vertical surfaces (backs) at 55°, and the bases at 90°.



**Fig. 2.** Section of the *Ima cavea* with the indication of surfaces on which releves has been taken: a - Bases (90°), b - Seats (0°-3°), c - Backs (55°)

### 2.2. LICHEN SAMPLING

Lichen colonization was evaluated on the basis of 27 releves carried out in 2009 following a floristic-sociological approach. It is based on a lichen diversity value (LDV) calculated as the sum of species frequencies in a sampling grid consisting of four 10x50 cm ladders, each one divided into five 10x10 cm quadrants.

The grid was placed at the centre of the surface to avoid disturbance effects from adjacent surfaces (spraying of water, shading, etc.) and to ensure an homogeneous lichen vegetation.

### 2.3. BIO-ECOLOGICAL CHARACTERIZATION OF THE FLORA

Identifications are mostly based on Clauzade, Roux [7], Wirth [8] and Smith *et al.* [9]. In addition other specialized texts were consulted. Nomenclature, ecology and distribution follow the on-line checklist of Italian lichens [10].

Five indices are used for an ecological characterization concerning substrate acidity (pH), solar irradiation, aridity and eutrophication. These indices are grouped in five classes. A species can belong to one or more classes depending on the width of its ecological range.

### 2.4. BIODETERIORATION

In order to estimate the biodegradation role of lichen colonization, the Index of Lichen Potential Biodeteriogenic Activity (LPBA) has been recently proposed by Gazzano *et al.* [11]:

$$LPBA = \log \sum_{ij=1-n} \{a_{ij}b_i[c_{ij}(d_{ij}+e_{ij})f_{ij}^{g_{ij}}]\}$$

The index has been calculated on the most colonized sector of the Theatre: the percentage cover was estimated by naked eye; following the Authors [11], maximum values were adopted for parameters b–g when no similar cases were available in literature. Concerning lithotype, we estimated allochthonous hard calcareous rock similar to travertine.

### 3. RESULTS

#### 3.1. LICHEN FLORA

The present epilithic lichen flora of the Theatre consists of 26 *taxa* with the predominance of common lichens typical of basic substrates such as *Aspicilia* spp. or ubiquitous species such as *Protoparmeliopsis muralis*. A few endolithic species were found e.g. *Rinodina immersa* and *Verrucaria* spp. Almost all species were already detected on natural stone outcrops surrounding the study area [12] but *Verrucaria calciseda* and *Caloplaca chrysodeta* are new to the Molise region.

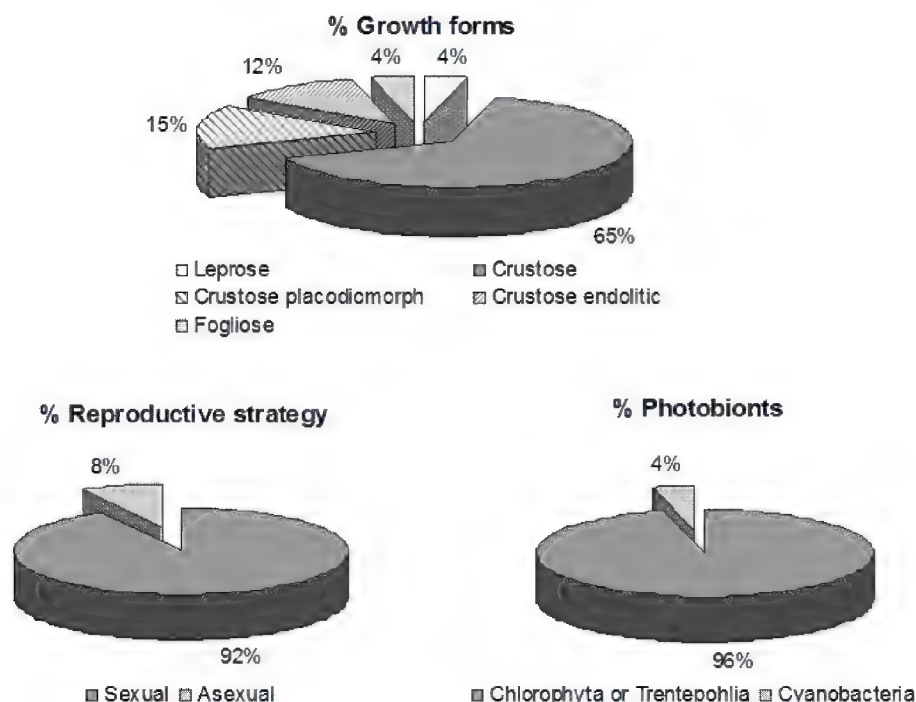
Growth forms percentages shows the predominance of crustose species (66%) and a relatively low presence of endolithic species (11%). 92% of the species have a sexual reproduction mode (Fig. 3).

Fig. 4 shows the incidence of the species in the ecological groups (from 1 to 5). The ecological indicators underline the predominance of common species typical of basic substrates in sunny, exposed conditions. *Collema cristatum* (L.) F.H.Wigg. and *Lobothallia radiosa* (Hoffm.) Hafellner, with samples very close to but out of the relevés, have been also considered for the bio-ecological characterization.

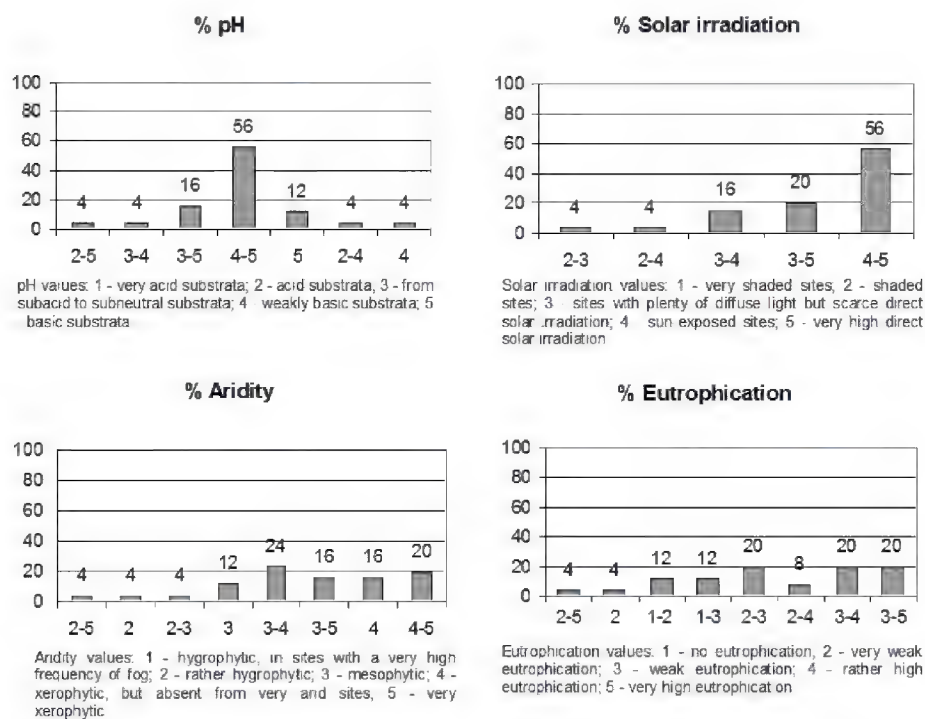
The lichen diversity values (LDV) increases turning from S-oriented to the N-oriented exposure (Tab. I).

**Tab. I. Relevés by species**

Releve no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Order	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Exposure	NNE	NNE	NNE	NNE	NNE	NNE	NNE	NNE	NNE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	SSW	SSW	SSW	SSW	SSW	SSW	SSW	SSW	SSW
Inclination	3°	3°	3°	90°	90°	90°	55°	55°	55°	2°	2°	2°	90°	90°	90°	55°	55°	55°	2°	0°	2°	90°	90°	90°	55°	55°	
<i>Acarospora cervina</i> A. Massal.	0	5	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	2	0	
<i>Aspicilia calcarea</i> (L.) Müdd.	5	5	5	5	5	5	5	5	5	3	0	5	5	5	5	5	5	5	5	1	5	5	5	5	5	4	
<i>Aspicilia cheresina</i> (Müll. Arg.) Hue	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Aspicilia contorta</i> ssp. <i>hoffmanniana</i> S. Ekman & Fröberg	4	5	4	4	0	2	3	5	5	3	4	5	5	0	0	5	5	5	5	5	5	5	5	0	5	1	
<i>Caloplaca alboprunosa</i> (Arnold) H. Oliver	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	
<i>Caloplaca chrysodeta</i> (Räsänen) Dombor	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Caloplaca holocarpa</i> (Ach.) A. E. Vade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	
<i>Caloplaca inconnexa</i> (Ny.) Zahlbr. v. <i>inconnexa</i>	4	4	4	0	5	5	5	5	5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	
<i>Caloplaca erythrocarpa</i> (Pers.) Zwackh	0	0	0	1	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Candelariella aurelia</i> (Hoffm.) Zahlbr.	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Catillaria fenticulata</i> (Ach.) Th. Fr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
<i>Dicranoma alboatrum</i> (Hoffm.) Flot	0	0	1	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Lecanora campestris</i> (Schaer.) Hue	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Lecanora dispersa</i> (Pers.) Sommerf.	0	0	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	
<i>Lecidea</i> sp.	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Placocarpus schaaereni</i> (Fr.) Breuss	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Protoparmia ops</i> s. <i>muralis</i> (Schreb.) M. Choisy	0	0	0	0	3	0	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Rinodina immersa</i> (Hörb.) Zahlbr.	3	3	2	4	5	1	4	3	2	4	3	3	5	5	3	4	3	5	4	2	5	5	5	2	2	2	
<i>Sarcogyne regulans</i> Körb. v. <i>regulans</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	
<i>Vemecania calciseda</i> DC. I.	2	0	4	0	4	5	1	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Vemecania fusca</i> Ny.	1	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Vemecania leucodes</i> (A. Massal.) Trevis	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Vemecania mamorea</i> (Scop.) Arnold	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Vemecania nigrescens</i> Pers.	5	5	5	5	3	2	5	5	5	0	0	0	1	1	1	5	3	1	0	0	0	0	0	1	2	0	
LDV	24	30	34	29	31	33	25	37	33	8	8	14	15	12	11	22	17	18	15	10	18	15	10	12	17	7	



**Fig. 3.** Functional and morphological characterization of the lichen flora of Pietrabbondante: occurrence (%) of growth forms, reproductive strategies and photobionts



**Fig. 4.** Ecological characterization of the lichen flora of Pietrabbondante

### 3.2. LICHEN VEGETATION

On the basis of floristic composition and species dominance in the relevés, it is possible to identify two main vegetation types belonging to *Aspicilion calcareae* Albertson em 1946. Roux 1978 (class *Verrucarietia nigrescentis* Wirth 1980), with a high percentage of cover in the area facing NNE. The two associations, *Aspicilietum calcareae* Du Rietz 1925 ex Roux 1978 and *Aspicilietum contortae* Kaiser 1926 ex Klem. 1955, are both typical of sun exposed and compact limestone.

*Aspicilietum calcareae* is an eliophilic community typical of horizontal or sub-horizontal surfaces of hard limestone also in variable conditions of humidity and temperature. In the area this community is poorly developed. The presence of *Verrucaria marmorea* could represent a transition step towards the *Farnoldio juranae-Verrucarietum marmoreae* Kaiser 1926 em. Roux 1978 (Roux, 1978; 1981).

*Aspicilietum contortae* is well characterized by the presence of *V. nigrescens* and *V. calciseda* and is a typical community of compact limestones preferring a higher degree of atmospheric humidity and less eutrophication than *Aspicilietum calcareae*.

### 3.3. LPBA

The index calculated is 4,23 (Tab. II). This value seems to be very high in comparison to the values found on similar substrates [11].

**Tab. II.** Calculation of the LPBA index for the NNE side of the Theatre

Species	a	b	c	d	e	f	g	s.s.c
<i>Acarospora cervina</i>	5	5	2	5	5	1	1	500
<i>Aspicilia calcarea</i>	40	5	10	5	5	1	0	200
<i>Aspicilia contorta</i> ssp. <i>hoffmanniana</i>	16,67	5	10	5	5	1	1	8335
<i>Caloplaca inconnexa</i>	1	5	10	5	5	1	1	500
<i>Diplotomma alboatrum</i>	1	5	10	5	5	1	1	500
<i>Rinodina immersa</i>	5	5	10	5	5	1	1	2500
<i>Verrucaria calciseda</i>	5	5	10	5	5	1	1	2500
<i>Verrucaria fuscula</i>	3,67	5	10	5	5	1	1	1835
<i>Verrucaria nigrescens</i>	6,67	5	10	5	5	1	0	33,35
<b>LPBA</b>								<b>4,23</b>

Legend. a: the cover, b: the reproductive potency, c: the depth of hyphal penetration, d: the physical action, e: the chemical action, f: volume of rock affected by hyphal spread, g: the bioprotective effect, s.s.c.: single species contribution

#### 4. CONCLUSIONS

The lichen flora of the sannitic theatre of Pietrabbondante is mainly composed by species usually growing on sunny and exposed calcareous rock. Wild populations of the same lichens are common in the surroundings. Therefore, the archaeological area itself does not seem to be an important conservation habitat for lichen species.

The lichen colonization increases from south to north oriented exposure where a species-poor lichen community develops into more complex and species-rich communities, as yet observed in similar situations [13, 14, 15, 16].

In addition to the floristic and vegetation study also an estimation of the deteriogenic activity of the lichen colonization has been carried out based on the index of Lichen Potential Biodeteriogenic Activity [11]. Lacking an interpretative scale of the index values, our calculation represent a contribute to the validation of this method on hard calcareous litotypes in the Mediterranean Region. The value of 4,28 for the LPBA seems to be very high in comparison to the values found on similar substrates and habitats but the lack of previous investigation and the consequent impossibility of a correct estimation of all the parameters requested by the LPBA method, could be the reason for this overestimation.

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## A METHODOLOGICAL ITINERARY FOR STUDYING MEDITERRANEAN HISTORIC GARDENS

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### Abstract

Historic gardens can be protected if they are appropriately identified and catalogued. According to article 6 of the Florence Charter (1981), ‘historic garden’ can refer to small as well as large gardens, and formal or landscaped ones. This definition allows us to include small gardens as ‘historic’, which are so common in the Mediterranean area, especially in Sicily, notwithstanding they often only have a small area of vegetation and lack adequate documentation which hinders accurate historical replication. So, surveys are needed which on one hand would quickly assess the numerous examples of gardens in the Mediterranean area and on the other would lead to a suitable understanding of the garden itself based mostly on analysing its current condition. The scarcity of historical documentation has meant resorting to direct surveys of all the components in these gardens today. As a result, a methodological itinerary for the analysis especially of biological historical garden traits was developed and was validated for 45 historic gardens in Eastern Sicily. The initial premise is that the garden is its own material document and its plants are its principle components. The methodology includes creating and compiling specific analytical charts to help with restoration and maintenance. The various charts, designed to facilitate compilation and subsequent processing, report on each single plant and its main morpho-functional traits as well as its botanical, cultural and ornamental ones. Making the plants primary components of a garden had led the research to an understanding of each individual garden as well as tying together common characteristics from a system point of view. The methodological itinerary helped us obtain useful data for cataloguing historic gardens which can subsequently be functionally applied to restoration and maintenance. It may also be put forward as a replacement for missing historical documentation, a common occurrence in the Mediterranean area.

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**Keywords:** garden conservation, garden restoration, plant survey, ornamental plants

### 1. Introduction

Gardens have long been used to express the interest, talents and values of notable personages and many historical gardens continue to instruct and inspire [1]. Because of its historical, cultural or artistic attributes, a ‘heritage garden’ can be regarded as being of local, regional, national or international significance [2]. According to article 2 of the ICOMOS (International Council of Monuments and Sites) Florence Charter of 1982 ‘the historic garden is an architectural composition whose constituents are primarily vegetal’. This kind of garden is ranked by the World Heritage Committee within cultural landscapes that represent the ‘combined works of nature and of man’, designed and created intentionally by man for aesthetic reasons [3, 4].

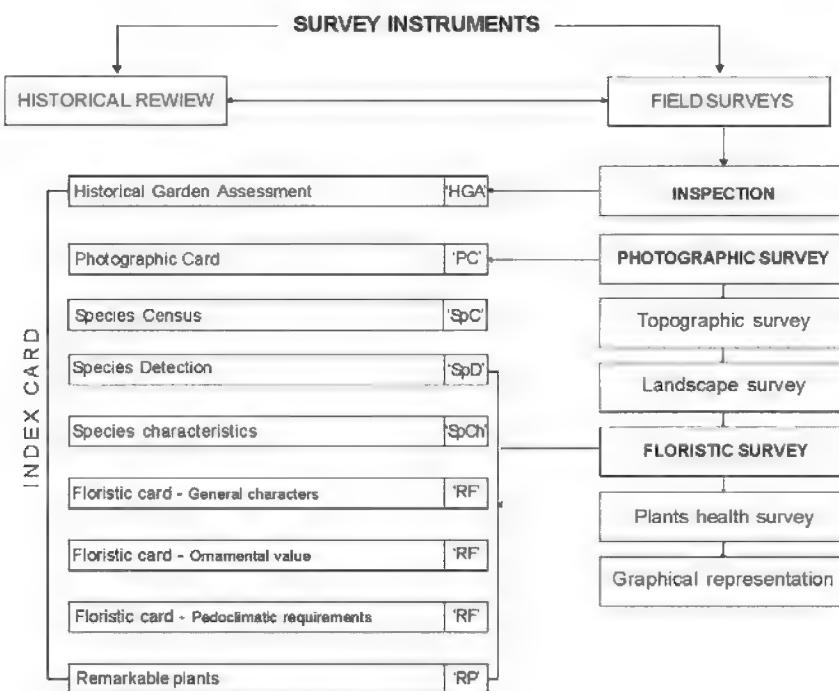
The knowledgeable appreciation of historic gardens has lagged behind that of historic buildings, but the last twenty or so years of the twentieth century saw a rapidly growing interest at all levels – popular, scientific and official. The ‘Comitato nazionale per lo studio e la conservazione dei giardini storici’ [National Committee for historic garden study and conservation] established in Rome in 1983, by the Ministero per i Beni Culturali e Ambientali [Ministry of Cultural and Environmental Heritage] for years developed initiatives for studying this cultural heritage. In particular, the Istituto Centrale per il Catalogo e la Documentazione [Central Institute for Cataloguing and Documentation] has produced version 3.00 of the PG Chart - Parks and Gardens, on which information may be inserted for registration to render it valid for insertion in the general Catalogue of Cultural Heritage [5].

This registration is not always calibrated for the characteristics of small gardens which are so frequent in the Mediterranean area, and especially in Sicily, but are nevertheless considered ‘historic’, notwithstanding they often only have a small area for vegetation and lack adequate documentation which hinders accurate historical survey. Besides, according to article 6 of the Florence Charter, ‘historic garden’ can refer to small as well as large gardens, and formal or landscaped ones. Because of the close connection between these places and human culture, the small gardens of Sicily are worth considering as a very important cultural heritage. Also for these examples we have to follow article 9 of the Florence Charter, in which it specifies that ‘the preservation of historic gardens depends on their identification and listing’.

For these reasons a methodological itinerary for Mediterranean historic garden analysis was carried out. The proposed surveys would have to be carried out such that, on one hand, they would quickly enable the assessment of the numerous examples of gardens in the project area and on the other, would enable a suitable understanding of the garden itself based mostly on analysing its current condition. This methodology was applied to different examples located in Eastern Sicily.

## 2. Methodology

The initial premise of the methodology is that ‘the garden is its own material document and its plants are the principle components’ [6]. The scarcity of historical documentation has meant surveying all the components expressed in the gardens today. The information was compiled, through different methodological steps (Fig. 1), into various charts to help understand the plant characteristics and programme plant maintenance. Of course the registration methodology of the Central Institute for Cataloguing and Documentation is taken into careful consideration. The activity, which was started in 2002, initially set out to identify ‘historic’ gardens as defined by Italian law (n. 1089 of 1939), and hence at least of 50 years of age and protected by the Italian Monuments and Fine Arts Office. Moreover, other gardens of over 50 years old but not protected were taken into account. This latter condition is very frequent in Sicily because of the small size of gardens and the lack of prestigious architecture these green areas were often overlooked. Each garden was surveyed throughout the year, especially in spring, when a lot of plants flower so as to easily identify the species. For each species, samples of plant exsiccates were prepared to allow us to identify the taxon. Taxonomic identification was carried out with specific reference texts [7, 8, 9, 10, 11 and 12]. In some cases, reference was made to plants in the Botanical gardens of Catania, Naples and Palermo. Each species was also assigned to one of the following morpho-functional groups: herbaceous, bulbous, shrub, tree, palm, palm-like, climber, aquatic and succulent.



**Figure 1** - Methodological scheme for studying historic gardens

## 3. Results and discussion

The methodology, organized in different steps, enabled the acquisition of information to better understand the function of the vegetal components of gardens. The study was predisposed to follow two lines of enquiry, one relating to the research and study of documentary evidence and the other to surveying the current state of the gardens (Fig. 1). The results of these enquiries have led to the compilation of data charts which relate to the methodological steps: inspection, photographic and floristic surveys. Each chart contains two identification codes (ID), one relating to the garden (ID garden) and the other to the province of provenance (ID province). This has made recognition of the garden/sample more immediate and also made handling the data easier. Furthermore, each chart was conceived and/or modified to facilitate compilation (multiple choice and/or with codes).

The first chart, ‘Historical Garden Assessment’ (HGA), represents a summary of the chronology, geography, typology, structure and general conservation of the site; from this data, the garden’s history can be inferred as well as its stylistic influences and current configuration (Fig. 2).

The ‘Photographic Card’ (PC) is based on a narrative through images of the architectural and vegetal components of the garden (Fig. 3). This chart can be used to trace structural, functional and seasonal changes over time constituting a historical archive.

Seven different chart models were used for the floristic survey. The ‘Species Census’ (SpC) chart lists all the garden plants and for each species its relative phenological state (V=vegetative, R=reproductive) (Fig. 4).

HISTORICAL GARDEN ASSESSMENT		'HGA'
Name	Property	<div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">ID garden</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 2px;">ID person</div>
Province	Municipality	
Address	Designer	
Century	Surface (m)	
Legislative protection		
<b>GPS</b> (coordinates UTM)		
<div style="display: flex; justify-content: space-between;"> <div style="width: 48%;"> <p><b>Typology</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Park</li> <li><input type="checkbox"/> Villa garden</li> <li><input type="checkbox"/> Cottage garden</li> <li><input type="checkbox"/> Roof garden</li> <li><input type="checkbox"/> Courtyard</li> <li><input type="checkbox"/> Cloister</li> <li><input type="checkbox"/> Others</li> </ul> <p><b>Stylistic influences</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Formal</li> <li><input type="checkbox"/> Informal</li> <li><input type="checkbox"/> Others</li> </ul> <p><b>Restoration necessity</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Yes</li> <li><input type="checkbox"/> No</li> </ul> <p><b>Original use</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Private</li> <li><input type="checkbox"/> Public</li> </ul> <p><b>Actual use</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Private</li> <li><input type="checkbox"/> Public</li> </ul> <p><b>Plant arrangement</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Parterre</li> <li><input type="checkbox"/> Topian</li> <li><input type="checkbox"/> Tree-lined</li> <li><input type="checkbox"/> Hedge</li> <li><input type="checkbox"/> Borders</li> <li><input type="checkbox"/> Others</li> </ul> </div> <div style="width: 48%;"> <p><b>Architectural components</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Peripheral wall</li> <li><input type="checkbox"/> Tower</li> <li><input type="checkbox"/> Terrace</li> <li><input type="checkbox"/> Steps</li> <li><input type="checkbox"/> Bridge</li> <li><input type="checkbox"/> Ruins</li> <li><input type="checkbox"/> Others</li> </ul> <p><b>Garden furnishings</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Statue</li> <li><input type="checkbox"/> Pot</li> <li><input type="checkbox"/> Pond</li> <li><input type="checkbox"/> Fountain</li> <li><input type="checkbox"/> Pergola</li> <li><input type="checkbox"/> Aviary</li> <li><input type="checkbox"/> Mosaic flooring</li> <li><input type="checkbox"/> Heraldry</li> <li><input type="checkbox"/> Others</li> </ul> <p><b>Plant health</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Good</li> <li><input type="checkbox"/> Moderate</li> <li><input type="checkbox"/> Poor</li> </ul> <p><b>General garden condition</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Good</li> <li><input type="checkbox"/> Moderate</li> <li><input type="checkbox"/> Poor</li> </ul> <p><b>Prevalent feature</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Historic</li> <li><input type="checkbox"/> Artistic</li> <li><input type="checkbox"/> Botanical</li> <li><input type="checkbox"/> Landscape</li> </ul> </div> </div>		
<b>Notes</b>		
<div style="display: flex; justify-content: space-between;"> Date Subject </div>		

**Figure 2 - The historic garden assessment card**

PHOTOGRAPIC GARD			PC
DIGNO'S VILLA	VCD	ID	
Plants configuration			Pc n.1

**Figure 3** – The photographic card

[illegible]

**Figure 4 - The species census card**

SPECIES DETECTION	
Scientific name _____	Common name _____
Garden _____	Address _____

**Location**

☐ Flowerbed

☐ Pot

☐ Others \_\_\_\_\_

**Distribution**

☐ Single

☐ Group

☐ Row

☐ Others \_\_\_\_\_

**Height**

☐ \_\_\_\_\_

**Trunk circumference**

☐ \_\_\_\_\_

**Canopy diameter**

☐ \_\_\_\_\_

**Age**

☐ Young

☐ Mature

☐ In decline

**Plant health**

☐ Excellent

☐ Good

☐ Medium

☐ Poor

**Injured organs**

☐ Root

☐ Trunk

☐ Branch

☐ Canopy

☐ None

**Necessary interventions**

☐ Felling

☐ Pruning

☐ Substitution

☐ None

**Prevalent feature**

☐ Botanic

☐ Urbanian

☐ Landscape

☐ Ornamental

**Notes**

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Date \_\_\_\_\_

Survey \_\_\_\_\_

**Figure 5** - The species detection card

The ‘Species Detection’ (SpD) chart is specifically for older plants and botanical rarities. It reports taxonomic information as well as plant location, setting, size and an estimate of age. Without going into plant pathology, some indicator of their state of health was included and any physical damage with relative maintenance. Finally, the prevalent feature of the plants was noted: botanical, utilitarian, landscape or ornamental (Fig. 5).

The ‘Species Characteristics’ (SpCh) chart is devoted to all the garden species reporting data on general character, ornamental value and pedoclimatic requirements (Fig. 6). The scientific name is cited according to the GRIN Taxonomy for Plants of the USDA and the International Plant Names Index [13, 14]. For the common name we referred to Penzig [15] and Pignatti [9], whereas the morpho-functional groups partially coincide with references in Graaf [16] and appear to be amply representative of the plant types used in Mediterranean gardens [17]. The information about ‘group’ and ‘height’ refer to ‘typical plants’ and were taken from literature [7]. The data referring to plant origin have been summarised in two different categories: native and exotic plants. The field referring to foliage characteristic provides two options: evergreen or deciduous, and of course the field is active only for perennials. The possibility of indicating the flowering and fruiting periods highlights two very important phenological aspects of ornamental value. ‘Ornamental value’ allows a multiple choice response given that each plant’s aesthetic value may be expressed through the leaves, flowers, fruit, etc. For pedo-climatic requirements, we partially modified the data field drawn up by Burte and Cointant [18]. In particular for the substrate, it is possible to choose soil type (sandy, silty, clay, loamy, peaty, chalky, etc.), texture (light, medium, heavy), pH (acid; sub-acid; neutral, sub-alkaline, alkaline), organic matter (poor, medium, high) and moisture (an appropriate scale was adopted that ranged from 1 to 5, where 1 is a dry substrate, while 5 was at field capacity). Other aspects are related to climatic zone (reference is made to 11 zones in the USDA Plant Hardiness Zone map [19], relative air humidity (a specific scale was adopted that ranged from 1 to 5, where 1 is very low relative humidity, and 5 when relative humidity is near saturation) and sunlight (full sun, full shade, partial/dappled shade).

At the end of the floristic surveys we were able to obtain a profile of the plants and their features for each single garden in relation to ornamental traits and season. The plant requirement data allowed us to summarise the agronomical traits of the garden and start organizing further maintenance.

This information about single species, integrated with literature data and direct observation allows us to create a specific chart for different species which includes aspects of botanical and cultivation requirements, ethno-botanical use and their most frequent use in Sicilian gardens (Fig. 7). This chart incorporating plant photographs may prove useful in understanding the role of the most common plants in the historic garden.

SPECIES CHARACTERISTICS

SpCh

Scientific name

Common name

Family

Origin

General character

Group

Height

Canopy Ø

Origin

Foliage characteristic

Blooming season

Fruiting season

EUR

AFR

AMR

ASIA

AUST

MED

Ornamental value

Shape

Trunk

Bark

Foliage

Flower

Fruit

Scent

Pedoclimatic requirements

Substrate

Texture

pH

Organic matter

Moisture

Climatic zone

Relative humidity

Sunlight

Figure 6 - The species characteristic card

REMARKABLE PLANTS

RP

SCIENTIFIC NAME

ID

GROUP

ID garden

ID province

Photo detail 1

Photo detail 2

Photo detail 3

Plant use

Family

Common name

Dialect name

Origin

Year of introduction

Description

Cultivation requirements

Historical notes, ethno-anthropological value

Use in Sicilian gardens

Figure 7 - The remarkable plants card



#### 4. Conclusion

To date, this methodological itinerary has been validated for 45 historic gardens in Eastern Sicily; some of these results have been presented in another paper [20].

The survey charts proved easy to use, summarising the information about the gardens, individual plants and hardscape components to give an informative global view.

They highlight how a simple, computerized tool can gather together a significant proportion of the features of historic gardens, especially the small ones more frequently found in Eastern Sicily and often lacking historical documentation, thereby piecing together evidence from disparate sources and creating a knowledge base of the historic garden and its place in cultural heritage.

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## ARCHAEOBOTANY AND CULTURAL HERITAGE IN THE MEDITERRANEAN AREA: THE RESEARCH OF THE PACEM - PLANTS AND CULTURE IN EUROMEDITERRANEAN AREA - NETWORK

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Among the sciences applied in archaeology, archaeobotany fills a crucial piece of the Cultural Heritage puzzle. It assists us in understanding how a population exploits the environment. The study of Archaeobotany allows researchers to explore the evolution of the cultural landscape <sup>(1,2)</sup> through the use of plants, which is at the core of understanding modern human impact and sustainability. These issues also include conditions of life and diet, the exploitation of domestic and wild plants, the relationship between environmental modifications and cultural patterns as a result of human settlements. Social responses to climate change are the result of both human perception of nature and adaptation to its changing environment. <sup>(3)</sup> As a follow-up to an EU PaCE project <sup>(4)</sup>, and under the same key-words 'Plants and Culture', we propose to extend our archaeobotanical network into Mediterranean countries. The main aim of this PaCEM network is to establish joint and coordinated associations with archaeological sites belonging to major ancient civilizations. In the communication we wish to present case studies from this research. Cultural landscape reconstruction, based on integrated micro- and macro-remains studies, is one of the last challenges for palynologists and archaeobotanists. The knowledge of past environments plays an important role in assisting archaeologists, historians, environmentalists, geographers and many other experts. A correct and adapted sampling strategy is at the base of all scientific investigations at archaeological sites; however, a univocal protocol can be difficult to assess. Recent studies point out that archaeobotanical sampling has not only to be carried out in the case of visible records, but should be carefully located within "anthropic" layers. It is clear that all known techniques for the archaeological recovery of plants and analysis conducted, should be applied consistently to all samples. Distinguishing signs of anthropic action, influence and impact by means of not-intentional or intentional plant management can be achieved not only by approaching the problem within a multidisciplinary framework, but also by parallel studies carried out both on pollen and macro-remains. It is only through the careful application of both forms of data collection and treatment, that a more complete picture of the past landscape can be achieved.

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<sup>(2)</sup> Morel J.-P., A.M. Mercuri (eds), 2009 – Plants and Culture: seeds of the cultural heritage of Europe. Centro Europeo per i Beni Culturali Ravello, Edipuglia Bari.

<sup>(3)</sup> "Mid-Holocene climate change in the Mediterranean region and its consequences". Special issue of The Holocene (Roberts Ch. N., Sadori L., Perez R. eds)

<sup>(4)</sup> "Plants and culture: seeds of the cultural heritage of Europe" PaCE project. (CLT2007/1.2.1/it-182; 15 November 2007-15 July 2009; coordinator A. M. Mercuri) – [www.plants-culture.unimore.it](http://www.plants-culture.unimore.it)

# PLANTS, HISTORY AND CULTURES IN THE MEDITERRANEAN AREA

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## 1. Introduction

Plants have always been important in human life as food, fiber, tools, etc. but also they have been used as medicine and during rituals. Thus, it may be inferred that they also play an important role in culture, traditions and beliefs of human beings. Moreover, the uses of plants and the knowledge of their properties and qualities usually underline a deep knowledge of the territory, its ecological equilibriums and may be the result of a long relationship between people and their local environment. Traditions, indeed are transmitted from one generation to the next generation of people who live in, and by means of, the local environment: so, traditions are enduring adaptations to specific places [1].

Recently, the important role of plants in culture has been recognized during the General Conference of UNESCO in 2003 [2]. Knowledge and practices concerning nature (and plants as well) were defined as "Intangible Cultural Heritage" which is worth to be protected as it is "a mainspring of cultural diversity and a guarantee of sustainable development". The discipline that studies this kind of knowledge is called Ethnobotany, which may broadly defined as "the study of the relationship between plants and people"[3]. This general definition has now evolved into a much broader meaning which also covers relationships that embrace the *symbolic*, *ecological* and *cognitive*, as well as the *human-plant relationship* in a modern setting [4,5,6]. Thus it is not only related to a mere use of plants, but it is enriched by traditions, beliefs and a deep knowledge of natural resources.

In the Mediterranean area many cultures and civilizations have interacted for millennia, but some of them had a key role in the diffusion and the study of plants. The Egyptians, for example, played a major role in supplying healing substances and in drug trades. Moreover, they were able to prepare perfumes (i.e. the Cleopatra's Guide to Beauty), they mastered the embalming process (using plants and resins), they were also the first to obtain paper from papyrus. Plants were also widely used as symbols: as for example the palms and nymphaeas. One of first documents found in the Mediterranean and reporting the use of plants (as medicine) is, indeed, the Ebers papyrus, from Egypt, which dates back to 1552 B.C. [7]. In the Greek culture, plants were also important: many of them, indeed, were associated to different gods and were hallowed. Many greek philosophers and physicians studied plants: Hippocrates, Aristotle and Theophrastus, who maybe was the earliest Greek writer on botany, are just few examples. The treatise *De Materia Medica*, written by Dioscorides, is an assemblage of information about the properties of about 1000 natural product drugs derived mostly from the plant kingdom. Its treatise has been considered the bible of medical botany for centuries. Romans had a great role in the study of plants as well (one of the most famous treatise is the *Naturalis Historia* of Pliny the Elder), but were also responsible for the diffusion of various plant cultivations (as for example the grapes and olives) all around the Mediterranean. Finally, Arabs were important merchants of Spices from the East regions of Asia (cloves, pepper, nut meg and nut vomix, etc.). Arab physicians, then, introduced many new aspects and upgraded the knowledge about herbs and their potential medical efficacy and safety (probably the most outstanding writer on medicine in Arabic was Avicenna) [8].

Considering this background, it is not surprising that many plants have common uses in the Mediterranean, well described in the ancient Greek, Latin and Arabian literature, as food, medicine and in religious practices. Somehow, these uses may be considered as an evidence of the old relationships among cultures in the Mediterranean area. Even though, there are many original uses of plants as each region developed its own uses, creating a well diversified panorama of ethnobotanical uses [7].

Nowadays, the spreading globalization process is a concrete threat to this kind of knowledge. Its preservation is more urgent than ever as it is disappearing in many places: nevertheless, in many Mediterranean countries, especially in remote areas, people still use many wild plants in everyday life.

The aim of this paper is, therefore, to provide an first view on the wide panorama of traditional uses of native Steno-Mediterranean plants (mentioned in the Italian flora [9]) across the Mediterranean countries. This information is uploaded in a database through which is also possible to infer differences and similarities of plant uses developed in different countries.

## 2. Methods

After an exhaustive search in ethnobotanical works, it was possible to create a database with around 1400 entries on ethnobotanical plants within the Mediterranean basin. The plants were screened out for medicinal or veterinary uses, for their use as food for humans and as fodder for animals, for handicraft manufacturing and for cosmetics.

The main part of data is from bibliographical sources, but where also included information gathered through field researches. The countries considered for this search are: Morocco, Algeria, Tunisia, Libya, Egypt, Israel (included the Palestine area), Lebanon, Syria, Turkey, Greece, Albania, Montenegro, Bosnia and Herzegovina, Slovenia, Croatia, Italy, France, Spain, Cyprus, Malta. However, it was not possible to find out any ethnobotanical research sited in Lybia, Montenegro, Bosnia and Herzegovina, Slovenia, while few data were available for Croatia, Albania

and Malta. Many papers (37) are related to specific areas, few works (3) are reviews on ethnobotanical uses within a country or region, some others (7) provide a comparison of specific ethnobotanical uses among Mediterranean countries. Another element of heterogeneity of the bibliographical sources was added by their focus: basically, the most part of studies dealt on medicinal plants, few were on wild food plants or/and other ethnobotanical uses.

Only native Steno-Mediterranean plants (included ferns) which grows in Italy (977 species) [9] were considered for the analysis of the differences and similarities in traditional uses. These species were thereafter filtered out for any ethnobotanical uses in other Mediterranean countries. The choice to limit the analysis to the Steno-Mediterranean plants has manifold reasons: these plants are generally restricted to the Mediterranean region and it is likely to found them in many countries facing the Mediterranean. Among these plants, were chosen only the ones found in Italy, both because its peninsula is in the middle of the Mediterranean and because Italy is the country with the greater amount of available data. Finally, the nomenclature of the species was updated [10,11,12] and the occurrence of these plants has also been evaluated within the Mediterranean countries through the Med-Checklist [13].

### 3. Results and Discussion

Many plants have one or more uses: it was possible to indicate an use of 304 plants out of the 977 native Steno-Mediterranean species. Among these plants, some have an use only within a country, in few countries or they may be widely used: in these last cases the use may be the same or similar, but also totally dissimilar. The different ways in which people use plants, indeed, are complex and dynamic [14] and researches continue to detect new or very rare plant uses, even in very well-known ethnobotanical plants [15]. Many plants are used in all countries where they are native both in the same and in a different way.

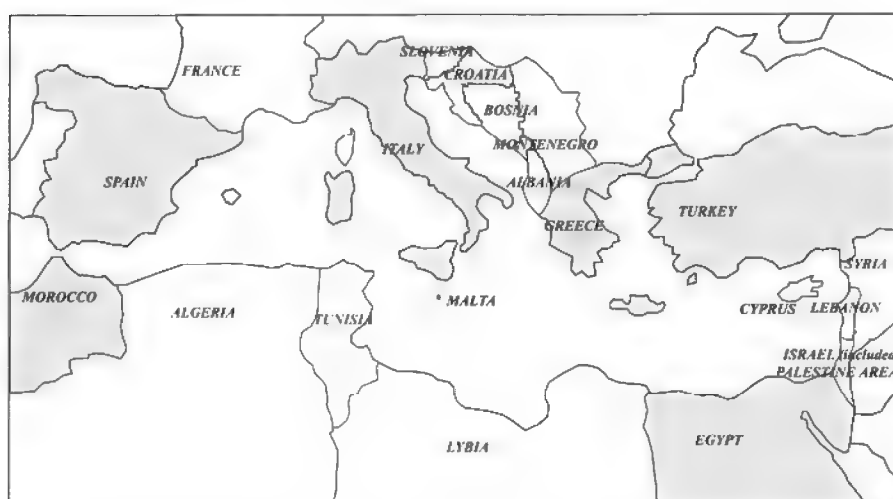
As it is not possible to show all the uses of plants and their distribution and correlation, only few of the most utilized species are described.

The first species, maybe one of the most known symbols of the Mediterranean area, is the olive plant (*Olea europaea* L.). It is retained a sacred tree all over the Mediterranean basin: it was worshipped by Greeks (it was also sacred to Athena) and it is one of the most important plants of the Bible. This plant, which is the sacred symbol of the cycle of life, has been used in ceremonies and rituals in the Jewish and Christian religions for millennia. Curiously, in Italy, olive oil is still used to find out if someone has the evil-eye on, thus for magical and ritual uses. Moreover, this plant has different medicinal uses and it is used to heal different affections (Tab. 1). Its areal extent cover almost all the countries of the Mediterranean basin (and it is used, anyhow, in many of them: as for example, in the Fig. 1 its use for treating diabetes (one of the most common medicinal use) is outlined and the countries which share this same use are grey shadowed. Finally, this plant is widely used as food and it is considered one of the main elements of the Mediterranean diet.

**Tab. 1.** Some of the medicinal uses of the olive plant, the countries where it is used and the relative bibliographic source.

USE	COUNTRY	USE	COUNTRY
Diabetes and liver problems	Egypt [16], Greece [17], Italy [18], Morocco [16,19,20,21], Spain [15], Turkey [22],	Laxative	Egypt [16], Middle East [25], Morocco [16], Tunisia [16]
Skin problems	Algeria [23], Israel and Palestine area [16,24], Italy [18], Middle East [25], Morocco [16], Spain [15,23], Turkey [16,22]	Digestive and carminative	Cyprus [23], Italy [18], Morocco [23,29], Spain [15]
Hypertension	Greece [17], Italy [18], Morocco [19,20], Spain [26,27]	Aphta and mouth affections	Egypt [16], Italy, [18], Morocco [16, 29]
Kidney stone and problems to the urinary system	Egypt [16], Greece [17], Israel and Palestine area [28], Italy [18], Middle East [25]	Hemorrhoids	Italy [18], Morocco [16,29]
Rheumatism	Greece [17], Italy [18], Morocco [16], Turkey [16]	Ear affections	Italy [18], Morocco [29]



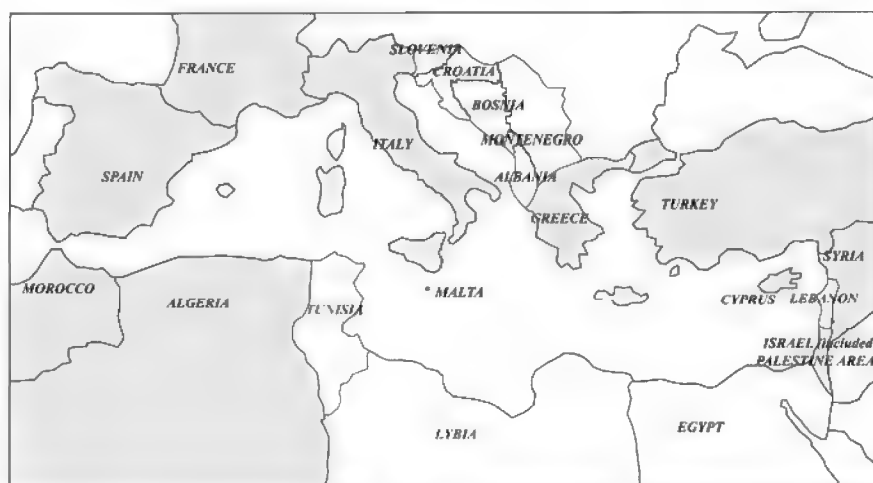


**Fig. 1 -** The countries where the olive plant is used to cure diabetes and liver problems.

Many plants with common uses have an old medicinal tradition in the Mediterranean area: in ancient Greece, bay laurel was consecrated to Apollo, it was a symbol of victory and triumph and later acquired the same meaning among Romans. In Latin the laurel wreath is called *laurus* or *laurea* from which comes the uses for *baccalaureat* in French, *laureato* in Italian, *baccalaureate* in English, *bachillerato* in Spanish. The use of *Laurus nobilis* L. as an aromatic plant is common in Italy [30,31,32,18,33,34] but also in other countries: Algeria [16], Cyprus [16, 35], France (Corsica) [36], Greece [16], Egypt [16], Israel [16,28] Malta [16], Morocco [29], Spain [16,37], Syria [16,38] Tunisia [16] ). This plant is also used as medicinal to treat a large spectrum of diseases (Tab. 2). The most common medicinal use is as digestive: the countries which share this use are indicated in Fig. 2.

**Tab. 2** Medicinal uses of bay laurel, the countries where it is used and the relative bibliographic source.

USE	COUNTRY	USE	COUNTRY
Digestive	Algeria [16,23], Cyprus [23], France (Corsica) [36], Greece [17], Israel and Palestine area [16] Italy [18], Morocco [16], Syria [38], Spain [23], Turkey [22]	Insomnia	Algeria, Italy [18] Morocco [22]
Arthritis, Rheumatism	Cyprus [39], Israel and Palestine area [24,28], Italy [18], Morocco [16] Tunisia [40] Turkey [22]	Snake and scorpion bites	Italy [18], Morocco [16], Turkey [22]
Hair loss	Italy [18], Greece [16,17], Turkey [22],	Diarrhea	Italy [18], Greece [17], Turkey [22]
Respiratory problems (cough, cold, bronchitis)	Egypt [16], Italy [18], Tunisia [16,40], Turkey [22]	Kidney stone and problems to the urinary system	Israel and Palestine area [28], Italy [18] Turkey [22]



**Fig 2 -** The countries where the plant is used as digestive.

Another plant widely used in the Mediterranean is *Ruta chalepensis* L. It was used to sprinkle to Holy water in the Roman rites of the Catholic church. It is known for this reason as the herb of grace, and it was among the first plants to be introduced by Europeans in America [41]. This plant is used to heal wound and rheumatisms, as anti-helminthic, digestive, pain-killer, or to treat eye affections. In Spain and Italy *Ruta* leaves are fried in olive oil against rheumatisms, while in the Corpus Hippocraticum they were macerated in wine or hydromel [41].

It is worth to mention that in other countries may be used other sister taxa of this plant (as for example *Ruta graveolens* L. or *Ruta montana* Mill.).

Another important plant is rosemary (*Rosmarinus officinalis* L.): this plant had a prominent devotional significance since Roman and Greek times: it was used as a love symbol, in weddings and in the cult of the goddess of love. This plant was later associated with Christian imaginary, and legends linked it to the Virgin Mary. Rosemary has also been connected with death. It probably played a role in death ceremonies of ancient Egypt, as branches of this plant were found with an Egyptian mummy. In ancient Rome, rosemary and olive branches were burned close to the body. Today, it is still planted on graves in many countries. For medicinal purposes it is used to treat rheumatisms, sore throats, bronchitis, kidney stone and problems to the urinary system as well as digestive and intestinal problems. Less common medicinal uses are for hypertension, diabetes and hypercholesterolemia.

*Myrtus communis* L. is also widely used in the Mediterranean. This plant has a religious meaning as it is deposited on graves in Algeria [42], in Libya [43], Syria [44,43] and Turkey [45,46,43] but also this was a custom of ancient Greeks [43]. This plant is very rich in essential oils especially cineole and limonene [42]. Myrtle is also used for medicinal purposes as digestive, for skin problems (wounds), cardiac diseases and for rheumatisms.

*Glycyrrhiza glabra* L. (liquorice) is also important in the Mediterranean pharmacopeia and it is widely used to treat respiratory and digestive problems, hypotension and hypertension, as diuretic and for mouth infections. Nowadays its extract is widely used to flavor refreshing candies.

Finally it is worth to mention the role of many of this plants in the Mediterranean diet, which is rich in vegetables, legumes, fruits and olive oil. Traditionally, many people within the Mediterranean basin consume a diversity of plants, which are often gathered from the wild creating different dietary pattern [47,48]. Some native food plants are: *Arbutus unedo* L. (Algeria [16], Greece [16,47], Italy [18,47], Spain [16,37,47,48], Tunisia [16]), *Asparagus acutifolius* L. (Cyprus [16,35], Italy [18], Spain [16], Syria [16]), *Brassica oleracea* L. (Algeria [23], Albania [49,23], Greece [48], Italy [18] and it is cultivated in many countries), *Ceratonia siliqua* L. (Algeria [23], Cyprus [16,35], Egypt [16], Greece [16], Israel and Palestine area [16,28], Italy [18], Morocco [16], Spain [16], Syria [16]), *Pistacia lentiscus* L. (Cyprus [16,35], Egypt [16], Italy [50], Israel and Palestine area [28], Lebanon [16], Morocco [16,29]), etc.

#### 4. Conclusions

The Mediterranean culture in general, but also the knowledge pertaining the plant-human relationship, is the product of a complex system of exchanges and relationships [7,51,52,53] which have lasted for millennia. The exploration of the wide and rich panorama of the traditional uses of plants highlighted both its value and the lack of knowledge on many areas. The creation of a comparative database was useful to find out similarities and differences among the traditional uses of plants in the Mediterranean area. In fact, shared traditions and cultural diversity are both important in enriching the cultural heritage of the Mediterranean basin, and both worth to be protected.

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## ANATOMICAL OBSERVATIONS REGARDING THE STEM OF THE DATE PALM (*PHOENIX DACTYLIFERA* L.) USED FOR CONSTRUCTION PURPOSES

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### Abstract

*Phoenix dactylifera* L. is a dioecious species, belonging to the monocotyledons (Class: *Liliopsida*). The date palm is well-known for its fruit production, the dates, which are the reason for the widespread distribution of this tree and for the creation of numerous cultivars with different characteristics. In this study, four date palm cultivars were investigated, using anatomical analysis: Ammari, Deglet, Thoory and Ftimi. The material examined had originally been used for construction purposes and differed in age. The estimated age of the artefacts from which the samples were taken ranges from ten to 100 and 200 years. The results of the analyses have shown that the principal cause of decay for palms are fungi. There is a positive relationship between the age of the sample material and cellular decay, caused by the presence of hyphae. Various reproductive elements, such as spores and conidia, were also abundant. Generally, there were few signs of attack by wood-eating insects. The older wood (100 and 200-year-old) was characterized by a reduction in the parenchymatous matrix surrounding the vascular bundles. As a consequence, the bundles separate one from another, a process which lends old palm “wood” its typical fibrous aspect.

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**Keyword:** date palm, *Phoenix dactylifera*, cultivar, anatomical characterization, decay.

### Introduction

*Phoenix dactylifera* L. is a dioecious species belonging to the monocotyledons (Class: *Liliopsida*). The date palm is well-known for its fruit, the dates, which are the reason for the widespread distribution of this tree and the creation of numerous cultivars with different characteristics. Palm cultivation represents the main source of earnings in many middle eastern countries (Zaid, 2001), where the total area dedicated to this production exceeds 175,000 ha (FAO, 2002).

The date palm is native to the desert regions of North Africa and the middle east. Known since ancient times, the palm was considered a symbol of fertility by the Egyptians; it was represented by the Carthaginians on their coins and used by Greeks and Romans as an ornament for celebrating victory.

Date palm leaves were an important secondary product obtained from the tree's cultivation. Leaves were used to plait baskets and other articles; the fibre extracted from the leaves was used to make ropes and string; whereas the material obtained from the stem, wrongly called “wood”, was used to construct buildings, including some of great cultural interest.

Although, in comparison with “real” wood, date palm “wood” has inferior physical-mechanical characteristics, in the past it was employed over the entire Sahel zone. It is still used today, especially in the reconstruction and restoration of historical buildings or country houses. In the past, it was employed in the construction of country buildings, the roofs of houses and places of work, where its good thermal insulation properties were particularly appreciated.

Palm “wood” and its leaves were also used for roofing the lanes in Moroccan, Tunisian (Fig. 1) and Iranian towns (El-Mously, 2001).

Palm wood is rarely used in the main structure of buildings, it is often employed for making small beams or other wooden elements of a secondary nature. However, palm wood sometimes has an important aesthetic and ornamental function. This is the case in many buildings in Mali, such as the Great Mosque of Djenné (Fig. 2).

The walls of the Great Mosque are made of mud bricks, baked by the sun and covered with mud plaster, which give the surface its typical smooth, plastic aspect. Sheaves of small palm-wood beams, 6-8 elements per sheaf, spaced out at regular 60cm-intervals, decorate the building. The sheaves also serve as scaffolding during the mosque's periodic restoration (Fig. 3). The historic city centre of Djenné, including the Great Mosque, was designated a World Heritage Site by Unesco in 1988.

Other important examples of this kind of architecture are the Great Mosque of Timbuktu and the Palace of the Sultanate of Zinder, in Niger.

This kind of African architecture and its traditional building techniques have recently been commended by ICCROM (Sidi & Joffroy, 2005), the International Centre for the Study of the Preservation and Restoration of Cultural Property, established by UNESCO in order to promote the conservation and restoration of monuments and sites of archeological, artistic and historical interest.

Although palm wood is widely employed in historical buildings, we do not know much about the material's performance in time, as studies on palm anatomy are not numerous (Tomlinson, 1990).

The objectives of this work are:

- to evaluate possible anatomical differences among the tested cultivars;
- to analyze the process of decay affecting sawn palm wood over a period of time;
- to determine the principal factors of decay in machine-cut material; and
- to find out if there are any differences in the resistance to decay among cultivars.



**Figure 1.** Typical use of palm wood as roofing material in North Africa.



**Figure 2.** The Great Mosque of Djenné, Mali.

### **An outline of the anatomy of the date palm stem**

The date palm stem is made up of vascular bundles (Arrigoni, 1973) inserted in a parenchymatous matrix (Fig. 4). The vascular bundles are generally composed of 2 or 3 metaxylematic vessels; the relative phloematic portion develops in proximity to the point of contact between the two vessels, on both sides. The phloem-xylem system occupies only a marginal portion of the bundle, a considerable part of which is made up of fibres that wrap the conducting elements like a sheath, thereby increasing the robustness of the bundle. The fibrous sheath, which is more or less abundant, develops irregularly within the bundles whose major axis, observed in transverse section, appears to be orientated in an apparently fortuitous direction (Figs. 4 and 6).

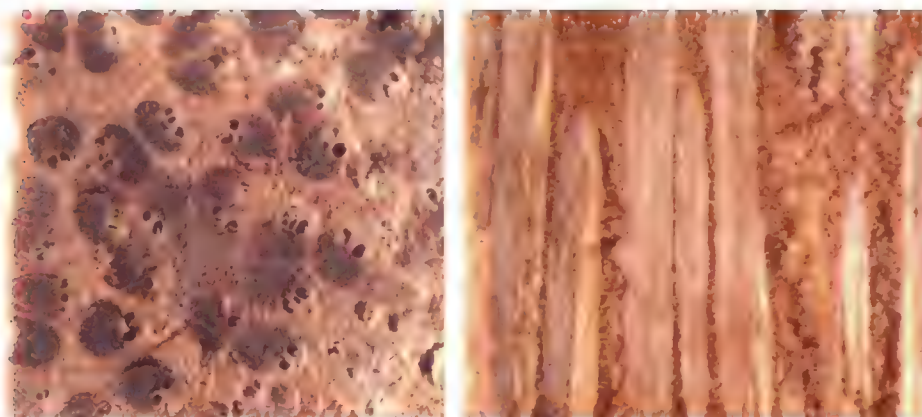
The consequence of this cellular arrangement is the lack of any three-dimensional cellular structure, which is found in real wood, with its transverse, radial longitudinal and tangential longitudinal sections. In palms, the planes of observation are limited to transverse and longitudinal sections.

The girth growth of palm trunks is not due to cambial activity, as is the case with trees (secondary growth), hence it is not connected to the tree's age. Palm trunks grow as a consequence of the division and increase of parenchymatous cells. This kind of growth is called "diffuse secondary growth" (Esau, 1977). Therefore, palms cannot be dated like other trees.

As it is difficult to establish the age of the material, there are no present studies on the relationship between palm "wood" and the age of the manufactured article. However, this is a matter of great interest, considering the frequent archaeological discoveries in desert and semi-desert areas.



**Figure 3.** Restoration of the Great Mosque of Djenné. Palm wood bundles are used as scaffolding.



**Figure 4.** Palm wood under a stereo microscope. Transversal (left) and longitudinal section (right).



### Materials and methods

Four date palm cultivars were investigated: Ammari, Deglet, Thoory and Ftimi, all coming from the oasis city of Nefta, region of Tozeur, in the south-west of Tunisia. The material, of various ages, was supplied by the University of Tunisi. The estimated age of the manufactured goods ranges from modern (10 years) to 100 and 200 years.

The samples consist of 50cm long strips (Fig. 5), two for each cultivar and for each supposed age (Table 1). Many anatomical observations were carried out on the strips, each of which was cut into a minimum of 10 sections. As mentioned above, the date palm is a dioecious species. In fact, the plant's gender is easily visible in a standing tree. It is, however, not possible to determine the gender of samples obtained from the stem. For this reason, differences due to gender were not taken into consideration in this study.

A transmitted light optical microscope (Olympus CX 41, with magnification 40X, 100X and 400X) was used. Digital images were acquired.

Quantitative analyses were carried out in conformity with the methodology and terminology reported by the IAWA Committee (1989). The Image Tool programme was used for measuring the cellular elements.

**Table 1.** *The material.*

Cultivar	Age (yerar)
Ammari	100
Deglet	100
Thoory	10, 100
Ftimi	10, 100, 200



**Figure 5.** *The material.*

### Results

#### *Quantitative analysis of anatomical elements among cultivars*

Table 2 reports the measurements of three anatomical elements (i.e. vascular bundle frequency, bundle diameter and vessel diameter) of the four date palm cultivars.

As far as the relationship between the anatomical elements is concerned, the frequency of bundles is inversely proportional to their diameter ( $r = -0,86$ ), whereas bigger vessels correspond to bigger bundles ( $r = 0,76$ ).

**Table 2.** *The quantitative analysis.*

	Ammari 100	Deglet 100	Thoory 10	Thoory 100	Ftimi 10	Ftimi 100	Ftimi 200
<b>Bundles Freq.</b> <b>(n/10mm<sup>2</sup>)</b>	10.3	10.0	13.1	8.8	9.4	9.3	10.4
<b>Bundles Mean</b> <b>Values (µm)</b>	738.61	882.43	648.50	868.68	834.19	821.80	815.32
<b>STDV</b>	86.36	123.60	69.26	163.05	144.29	149.76	219.07
<b>Vases Mean Values</b> <b>(µm)</b>	168.54	187.47	107.62	222.03	186.96	129.66	181.29
<b>STDV</b>	34.71	31.73	14.88	47.29	46.83	24.72	31.14



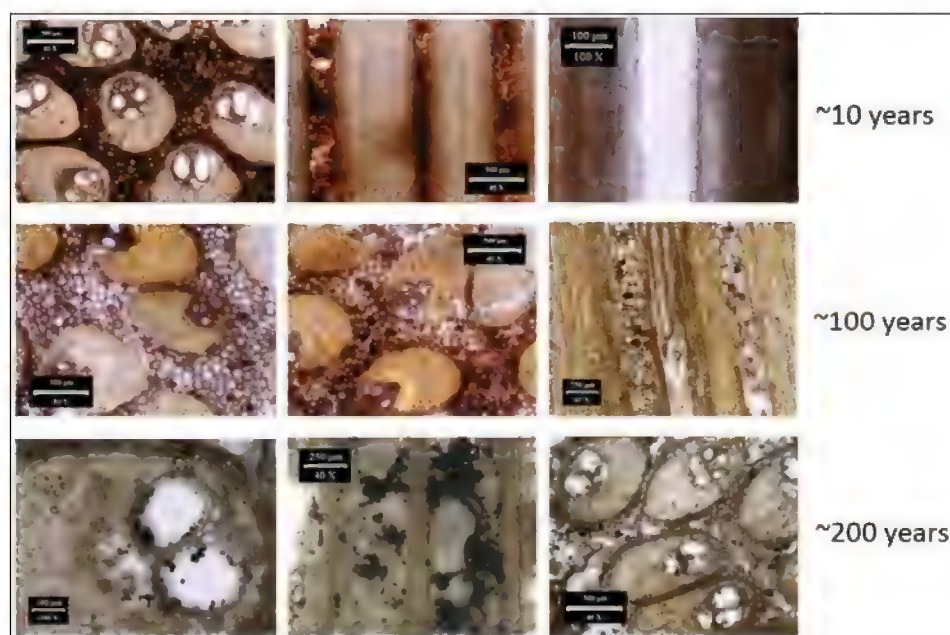
### *Rate of decay with passing time*

Within samples of the same palm cultivar, the amount of decay increases with the sample's age (Fig. 6). In particular, the parenchymatous matrix in the youngest samples is still substantial and coherent, which includes the vascular bundles and a vessel lumen that is always free from possible agents of decay. With increasing age, the parenchymatous matrix tends to deteriorate until it disappears completely. In 200-year-old samples it is absent. The vascular vessels appear incoherent and often the vessel walls are partially eroded.

### *Decay agents*

The most important agents of decay are fungi, which are notable in many forms: hyphae among the cells, in both vessels and parenchyma, spores, conidia and so on (Fig. 6).

Fungi are the principal cause of decay in the parenchymatous matrix. On the other hand, there are very few signs of insect attack. There is another important alteration on the external surface of the samples, which indicates that the decay is due to abiotic agents, such as ultra-violet rays and other atmospheric agents.



**Figure 6.** Cultivar Ftimi. In the top row the material is more recent, in the bottom row it is about 200 years old.

### **Discussion and conclusions**

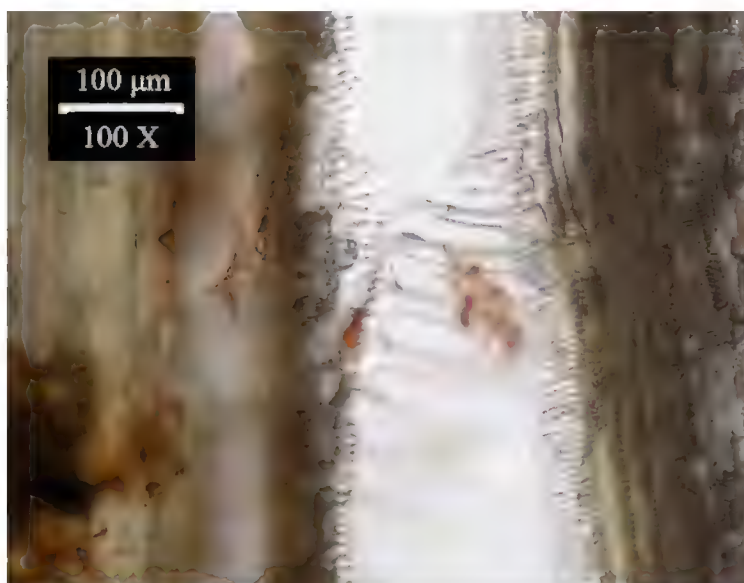
The average values variation of the vessels diameter, the diameter of the vascular bundles and their frequency per  $\text{mm}^2$  is higher in a same cultivar rather than among the cultivars (Table 2). The test F on the variation analysis corroborates this observation. So there are not differences which allow to distinguish the four cultivars from an anatomical point of view. The possible differences are likely to be due to many causes, as, for example, a different location of the sample inside the palm trunk: more or less internal, higher or not so high from the ground.

It is interesting to stress that only in the cultivar Ftimi some perforations have been observed (Fig. 7), while there is an important difference as regards the composition (with a colour varying from red to black) and the quantity of compounds, contained in the parenchymatous cells.

From an anatomical point of view, the direct relation between the dimension of the vascular bundles and the average width of the vessels is very interesting ( $r = 0,76$ ,  $p < 0,05$ ). Although the vessels component in the bundles is rather small (about 20% on average), greater vessels generally correspond to greater bundles.

Usually elder wood (100 and 200 years) is characterized by a rarefaction of the parenchymatous matrix which surrounds the vascular bundles. As a consequence there is the separation of the bundles one from another, a process which gives old palm “wood” its typical fibrous aspect. Together with the parenchymatous matrix decay there is also a general impoverishment of the bundles cellular walls, in relation to fungi attack which is often very strong.

Just as it happens for wood, fungi are the principal cause of decay. There is a positive relation between the age of the material and the cellular decay caused by the presence of hyphae. Various reproductive elements such as spores and conidia, are abundant. It is also evident the action of the abiotic elements, as the luminous radiation, which have acted with a gradient from the outside to the inside of the single elements. On the contrary there are few signs of attacks by wood-eating insect.



**Figure 7.** Scalariform perforation plate in the Ftimi cultivar.

The use of palm wood in structures of historical interest as the Great Mosque of Djenné or Timbuctu is often combined with other material liable to deteriorate: mud, wood, stones (Sidi and Joffroy, 2005). The action of these biotic and abiotic decay agents on these elements is often ravaging. Suffice it to think of precipitations - light but often very strong- which erode the building.

The action of the rain, besides breaking the material up, makes the environmental conditions fit for fungi attack which quickly destroy the biological material such as the palm “wood”.

This is the reason why the buildings which traditionally employ the date palm trunk undergo little and frequent restoration works. As a consequence, even if these buildings are very ancient, they are often completely rebuilt.

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## XILOLOGICAL ANALYSIS: A CONTRIBUTION TO THE HISTORY OF THE “GALLERIE” OF CASTEL GANDOLFO (ROME)

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### Abstract

The ancient trees in parks, gardens and avenues are the historical evidences of an aesthetic choice of the trends and inspirations of the designers. They also represent a valuable source of information on events that occurred during their existence. Xylological analysis conducted on the trunk sections make it possible to determine the age of the trees, thereby estimation of the plantation period was possible with a sharp precision as well as to identify growth anomalies which could mark specific events, such as climatic, biological or antropic incidents, occurred over time. Even though, the trees could be dead, their stump could be found which is a valuable research tool despite the absence of written records.

The aim of this study is to determine the age and origin of the *Quercus ilex* L. trees by analysing the annual rings identified on the sectioned disks.

Four stumps of *Quercus ilex* L. were obtained from the “Gallerie” (avenues) leading to the Pope’s historical residence at Castel Gandolfo and were sectioned from the basal region.

The annual rings from the sections reveal that all the trees are the same age and are placing their first years of life in the mid-nineteenth century. The characteristic features of the annual rings also reveal that the trees are of asexual origin.

In conclusion, this study proves that xylological analysis is an interesting approach for accurate understanding of historical events in the urban systems and for reading evolutionary processes of the green component which undoubtedly have an “environmental” value as well as decorative, historical and artistic ones.

**Keywords:** *Quercus ilex* L.; xilology; radial growth; avenue; Castel Gandolfo.

### 1. INTRODUCTION

The ancient trees in parks, gardens and avenues are the historical evidences of an aesthetic choice of the trends and inspirations of the designers. In addition to the ornamental, historical and artistic value urban trees have an active function improving quality of the urban environment. The urban forest can mitigate the climate of cities [1]. This is a common experience to people who attended forests and urban parks, especially in the summer months and they provide to Carbon dioxide sequestration [2].

They also represent a valuable source of information on events that occurred during their existence.

The “Galleria di sopra” and the “Galleria di sotto” are historical avenues in the town of Castel Gandolfo (Roma, Italy) and they connect Castel Gandolfo to Albano town. These avenues determine a way around the complex of the Villa Barberini, the Pope’s historical residence at Castel Gandolfo (Fig. 1).



**Fig 1.** The historical avenues (Galleria di sopra and Galleria di sotto) around Villa Barberini.

They are due to the prince Maffeo Barberini, ascended to the papal throne under the name of Urbano VIII in 1623. The Gallerie follow ancient tracks of Roman roads.

These avenues were lined with large holm oaks (*Quercus ilex* L.), and their crowns were joined in a tree canopy for “*ameno passeggio riparato dal sole a mezzo di grossi alberi*” (a pleasant promenade sheltered from the sun by big trees) [3].

Actually the avenues are 2995 m long, and *Quercus ilex* L. is the predominant species.

*Quercus ilex* L. is the main characteristic species of Mediterranean woodland. It is a mesomediterranean and a oromediterranean tree where termic condition are favourable [4] [5]. It can survive to severe drought but growth is reduced [6] [7]. The vessel distribution in xylem is typical of diffuse porous wood. Rings boundaries are detectable, even if sometimes with

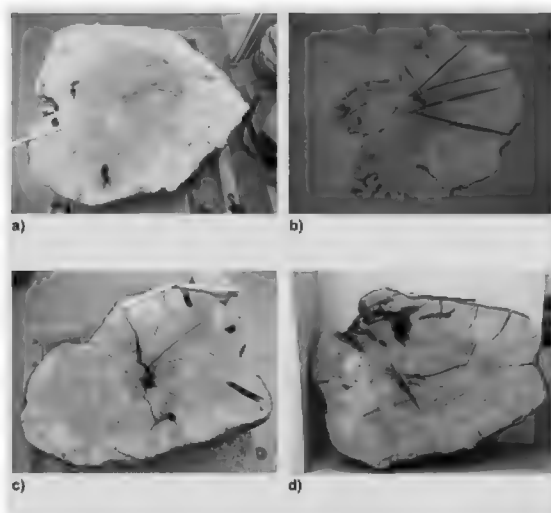
difficulty: dating difficulties have limited the number of dendrochronological investigations [8] [9].

In the avenues area, criticalities have been detected due to phytosanitary problems and to irregular and heterogeneous distribution of trees size classes, caused by cuttings for the safety.

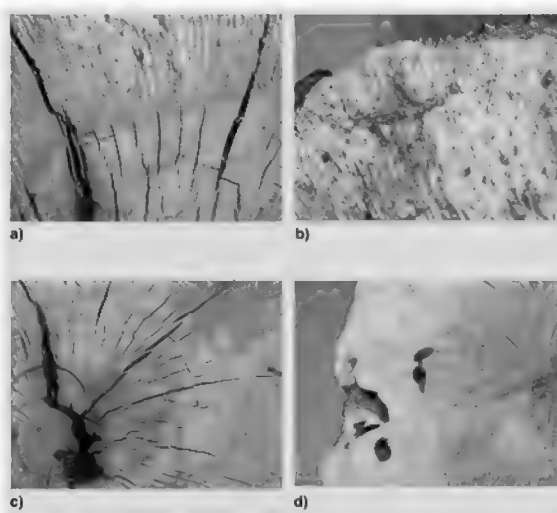
The Provincial Administration of Rome is the owner of these areas and it has promoted a study about these historical avenues which are of great interest from landscape and historical significance.

So the Administration financed a management plan to establish maintenance and care of the trees, to ensure their preservation, and safety of avenues users and inhabitants. The preliminary study was complex and involved many techniques and scientific skills [10].

The aim of this study is to determine the age and origin of the *Quercus ilex* L. trees by analysing the annual rings identified on the sectioned disks. This report contains the contribution of xilological analysis to better understanding the history of the avenues.



**Fig 2.** a) Disk n. 1 from tree "Cet 4" in Galleria di Sopra; b) Disk n. 2 from tree "Cet 3" in Galleria di Sopra; c) Disk n. 3 from tree "Cet 1" in Galleria di Sotto; d) Disk n. 4 from tree "Cet 2" in Galleria di Sotto.



**Fig. 3.** The basal zone was affected by injuries because urban environment. a) Sapwood affected by rot fungi; b) Scar tissue and xylem biodeterioration; c) Ring and radial shake d) Insects large tunnels.

## 2. MATERIALS AND METHODS

Four stumps of *Quercus ilex* L. were obtained from the "Gallerie" (avenues) and were sectioned from the basal region. The trees were felled for safety or phytosanitary purposes at different time.

Xilological analysis are designed to estimate the age and growth abnormalities that may be witnesses to particular climate or biological events occurring over time. The disks surface was cut and polished with cutter aid.

Observations were conducted at a monocular that allows a magnification of 8 times. The growth rings were identified along radial directions from the bark to the pit. Sometime the rings were not always easily identifiable, so the ring boundaries were marked so that subsequent widths measurements were not overly costly in terms of time.

Measurements of growth rings widths were performed using a stereomicroscope with a magnification of 6, 16 and 40 times. Most appropriate magnification was chosen. Each single tree curve was visually compared and synchronization attempts were been tested with statistical methods.

## 3. RESULTS AND DISCUSSION

Basal disks are not always regular (Fig. 2). The presence of basal buttresses determines a taper which induces to differences of ring thickness and anatomical anomalies. Furthermore, the tree basal zone was affected by injuries because urban environment. The consequences are removal of xylem, scar tissue, biodeterioration, and sometimes insect tunnels even large (Fig. 3).

Basal disks are optimal, therefore, to estimate the age of the trees, but have many drawbacks for the rings analysis. For ecological, biological reasons and even for operational simplicity sections or cores at breast height are preferred [11]. According to recent studies it seems possible to use samples taken at stump height for dendroclimatic studies in order to obtain ring chronological sequence of maximum length [12].

Disks characteristics are shown in the table I.

Age determination is usually carried out by counting the annual rings formed on a cross section of the trunk, near the collar. This area is not always readily identifiable or samplable, so the growth rings were detected on the sections taken near ground. This age is a cambial age. The age is estimated as the age reached from the inner ring at considered height.

To estimate the tree age, a number of years must be added as a correction factor. The years number is proportional



to the section height, to the growth rate of the species, to the particular conditions of the tree.

Since the determination is made on basal disks, the age of the tree does not differ much from the rings number found.

The trees are dated between 135 and 153 years old (Tab.I). There is a difference between the older and younger of 18 years. These trees are almost contemporary. In fact, sampling may have been unequal height from collar. So they place their first years of life in the mid-nineteenth century.

**Table I.** Disk dimensional characteristics. The ring number is the estimated age of the trees.

Disk	Cartographic code	Maximum diameter (cm)	Minimum diameter (cm)	Sapwood area (m <sup>2</sup> )	Heartwood area (m <sup>2</sup> )	Mean ring width (1/100 mm)	Ring number
1	Cet 4 Galleria di Sopra	84	75	0,32	0,18	342,4	135
2	Cet 3 Galleria di Sopra	98	63	0,39	0,12	330,7	143
3	Cet 1 Galleria di Sotto	76	54	0,25	0,08	219,9	153
4	Cet 2 Galleria di Sotto	80	65	0,24	0,17	240,5	151

**Table II.** Growth rings characteristics of the sequences from pit to bark.

Disk	Mean width (1/100 mm)	Standard Deviation	Minimum value (1/100 mm)	Maximum value (1/100 mm)
1	211	126,5	74	606
2	661	304,9	75	1241
3	258	101,8	61	452
4	387	213,2	18	725

**Table III.** Growth rings characteristics of the first 30 growth rings of the section from pit, divided into 10 rings blocks.

	Disk	Mean ring width (1/100 mm)	Standard deviation	Minimum ring width (1/100 mm)	Maximum ring width (1/100 mm)
From 1 to 10 rings	1	111	21,9	74	140
	2	887	190,9	600	1241
	3	314	108,0	152	452
	4	305	157,3	170	604
From 11 to 20 rings	1	207	44,7	142	271
	2	741	219,9	333	981
	3	266	74,1	173	416
	4	428	229,5	128	670
From 21 to 30 rings	1	315	161,1	139	606
	2	413	289,6	75	881
	3	194	89,5	61	314
	4	429	240,2	18	725

In a natural holm oak coppice in Corsica similar age was found for natural mortality of old trees [13].

The question concerning the stand origin has been analysed with different approaches (historical, landscaped, artistic, urban planning, xilochronological, environmental and socioeconomic approach) because the "historical" places can not be separated from the "environmental" place [14]. These avenues have undergone changes of use from path for a "pleasant walks" sheltered by large trees to a road subject to increasing traffic flows. The need for roadway enlargement and modifications induced by urban growth have greatly changed over time the dimensional and topographic trees distribution, the aesthetic features of the remaining holm oaks and the species composition of some avenue part (in Galleria di sopra, *Ligustrum* sp. trees have replaced the holm oaks, too large for the size of the road).

Therefore, the trees distribution shows that a predetermined alignment is no longer present, as described in documents and graphic representations of the Barberini archive preserved in the Vatican Library. Xilological analysis was conducted to interpret the green component origin of Gallerie.

Rings widths were measured under a stereomicroscope on the disks. The curves describe the ring width on the basal disks (Fig. 4).

Generally rings widths are large and they show that the environment is favorable to the *Q. ilex* L. growing even in older age (Tab. II).

The ring chronologies show a strongly individualized trend. So the synchronization statistic parameter reliability is poor. For this reason, a mean curve representative of the general behavior in this context was not built up.

It must be stressed that the interventions on the tree crowns (topping, pruning, etc.) have influence on the growth rings, with possible width reduction in relation to the photosynthetic canopy eliminated amount. Indeed, the maintenance activities over time have focused on removing branches or large trees. Unfortunately, operations were performed in a state of emergency to allow the use of the area in safety for people and property. During the roadway enlargement for the passage of buses and trucks, pruning specific interventions were implemented for the raising of the crown and the removal of dead branches.

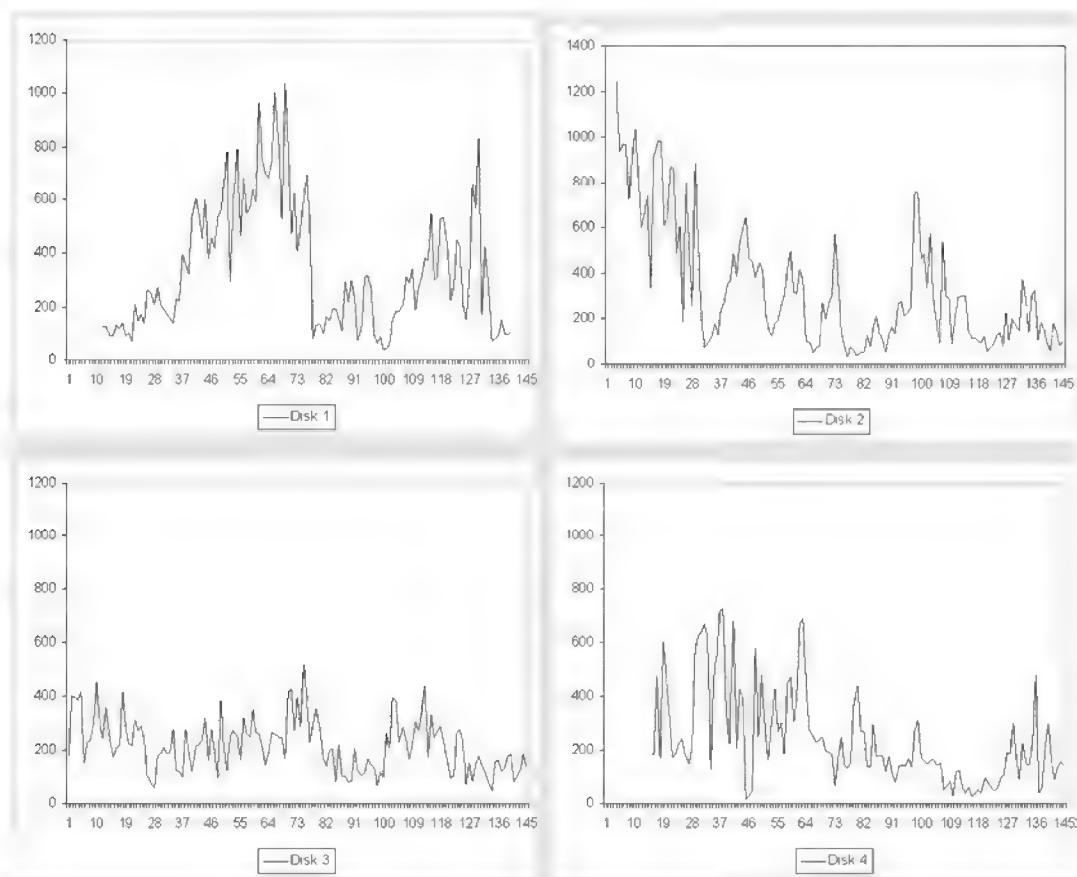
Therefore, trees management was characterized by different operating modes for intensity and location. The variability among trees was observed in all stage of growth. Thus, trees rings growth, which is characterized by great individuality, likely can be related to these anthropogenic interventions, because they do not synchronize the growth such as climate can do.

In addition, table III and figure 5 show that the rings around the pit are large.

It can therefore reasonably assume that trees are originated from shoots that have emerged over time, because natural selection or cultivation purposes.

Broadleaves can reproduce vegetatively. This capability is used in the hardwood forests that take the name of coppice. This kind of forest regeneration allows an early production of shoot and so a fast land cover. The new shoots are taking advantage of a large root system that support fast growth. So every stump can power many shoots. Over time, the competition makes a natural selection on the stump and the number of shoots decreases. This selection is carried out by forest managers to maintain a reasonable number of shoots in relation to the stump size. In some cases, for example, when conversions are made from coppice to high forests, only one shoot is left. By the time it takes on the shape of high forest trees. The growth rates of a tree born of seed can be differentiate from a coppice shoot. The tree rings width is small in stem originating from seed, and they remain small particularly when growth up under forest cover.

Also Galleries inspection has provided additional elements: there are very large stumps indeed. Individuals morphologically similar to those studied are noted on stumps. Selection has consolidated a single young shoot. Moreover, the stumps have produced vigorous shoots, after phytosanitary cutting.



**Fig. 4.** The curves describe the radial growth (1/100 mm) year by year on the basal disks.

#### 4. CONCLUSIONS

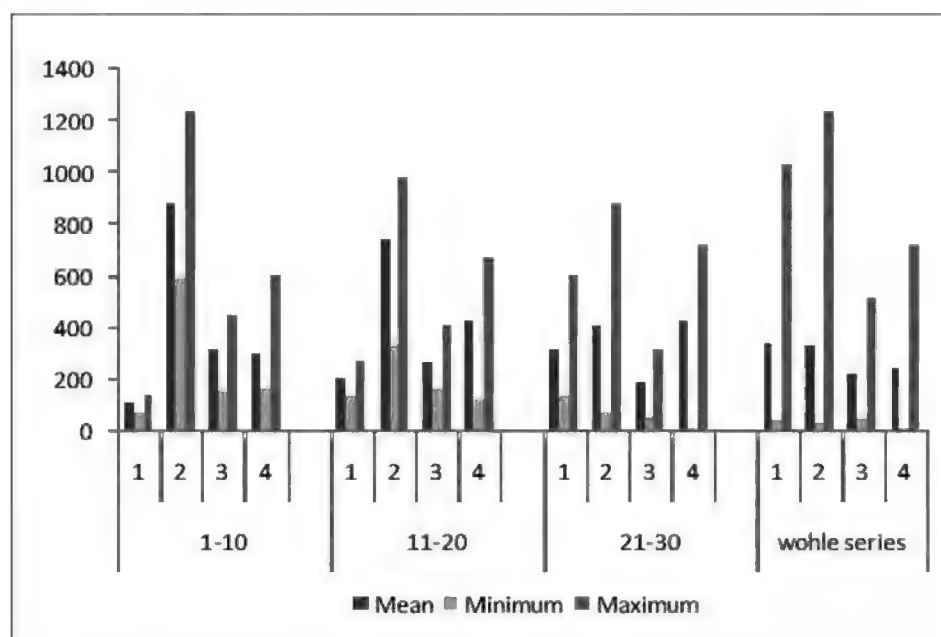
In conclusion, this study proves that xylological analysis is an interesting approach for accurate understanding of historical events in the urban systems and for reading evolutionary processes of the green component which undoubtedly have an "environmental" value as well as decorative, historical and artistic ones.

The annual rings from the analysed sections reveal that all the trees are the same age and are placing their first years of life in the mid-nineteenth century.

The characteristic features of the annual rings also reveal that the trees are of asexual origin. So they are shoots that have emerged over time, because natural selection or cultivation purposes.

The survey makes necessary to emphasize another aspect of the results. To understand the dynamics of this urban ecosystem, extensive surveys over time are needed.

Claiming that the evidence determined today can be considered definitive is an illusion in a period of change, including climate. Like the restoration of works of art, the management of Gallerie must be monitored for effectiveness and responsiveness over time.



**Fig.5.** Widths (1/100 mm) of the first 30 growth rings of each sections (from pit), divided into blocks of 10 rings. The rings around the pit are large.

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## **MULTIDISCIPLINARY APPROACHES FOR THE STUDY OF CULTURAL HERITAGE: THE EXAMPLE OF VIRTUAL ANTHROPOLOGY**

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Recent advances in scanning techniques offer many new possibilities for the analysis of the objects that make up our anthropological cultural heritage. These techniques, often referred to as the tools of “virtual anthropology” (VA), apply both to the surfaces of objects and to their solid interiors. After digitization, data samples can be submitted for systematic studies of their information content, including statistical, geometric and morphometric analyses in arbitrarily large samples.

The use of these nondestructive scanning methods supports preservation, analysis and documentation of the anthropological heritage. This is particularly pertinent when the original artifact has been lost and must be studied in reproduction, or when the study concerns human perceptions of an object rather than the object per se. VA methods include the virtual libraries that enhance communication between academic networks, the preservation of virtual copies of fragile or endangered artifact, and algorithms for reconstruction of damaged objects from fragments. Three-dimensional displays are a compelling medium for visualization and dissemination of objects and findings, whether for scholars or for the broad public, whether for conferences or for museum vitrines.

Our presentation introduces diverse scanning devices, including structured-light three-dimensional surface scanners and  $\mu$ -CT scanners, and presents several examples of workflow in the field of virtual anthropology that illustrate many of the potential applications of these methods, which lie at the crossroads of anthropology, cultural heritage and optical metrology.

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# A STUDY OF MICROBIAL COMMUNITIES COLONIZING ARCHAEOLOGICAL SITES IN THE PHLEGRAEAN FIELDS (NAPLES, ITALY)

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## Abstract

One of the most common causes of damage to monuments and archaeological sites is represented by organic incrustations (biofilms) developing over them. The incrustations are a consequence of the development of biodeteriogen organisms as bacteria, algae, mosses, lichens and fungi.

The present work deals with the study of bioincrustations of several monuments in the Phlegraean Fields, a volcanic area in the north-west of the city of Naples (Italy). Investigated sites include the Cave of the Sibyl, the Temple of Apollo, the *Stadium of Antoninus Pius* and the *Piscina Mirabilis*. All monuments are built with volcanoclastic rocks, such as tuff and piperno, important building materials since ancient historical times.

Microorganisms composing the bioincrustations were identified by using optical and electron microscopy, as well as by a molecular approach which combined DGGE (Denaturing Gradient Gel Electrophoresis) fingerprinting with the screening of 16S and 18S rDNA clone libraries by DGGE and sequencing. In addition, a SEM microanalysis allowed identification of various inorganic elements (Si, Ca, S and Al) deriving from the organic components of bioincrustations and in turn from the substratum of the sites.

Examined samples from all sites showed taxonomic homogeneity in the microbial composition of biofilms. Cyanobacteria and algae were particularly abundant due to environmental conditions favoring their growth, such as penumbra, high values of humidity and occurrence of brittle rocks. We identified the cyanobacteria *Leptolyngbya* sp., *Synechococcus* sp., *Nostoc commune*, *Chroococcus* sp., *Aphanothece* sp., and *Oscillatoria* sp., the green algae *Chlorella* sp., *Pseudococcomyxa* sp., *Scenedesmus* sp., the diatom *Pinnularia obscura*, the red alga *Cyanidium* sp., as well as the mosses *Brachythecium* sp., *Hypnum lindbergii*, *Pottia truncata* and *Bryum* sp.

Among not-invasive techniques employed to prevent the growth and/or eliminate the bioincrustating microorganisms, we have obtained interesting preliminary results by using specific biopesticides and a technique based on the use of microwaves.

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**Key words:** Biofilm, DGGE, Monuments, Phlegraean Fields

## 1 Introduction

Previous studies have suggested that endolithic communities are among the simplest microbial components of ecosystems (1). The endolithic environment is an ubiquitous substratum for microorganisms that play an important ecological role in these particular habitats, where the microbial mats grow in the last few millimeters of rocks.

Physical and chemical properties of rocks, their direction of exposure and climate influence the specific microbial composition of the endolithic biofilms (1). The microbial mat develops on the rock surface, giving rise to colored patinas and incrustations and directly participate in decay processes, causing aesthetic modifications and structural damage; primarily algae, in particular green algae, are involved in such processes (2,3). Algae and cyanobacteria are among the most frequent organisms found on rock surfaces; bacteria, fungi, mosses and lichens can also occur. Cyanobacteria and algae are abundant both as unicellular and colonial forms, as well as filamentous forms, although the latter show less diversity (4).

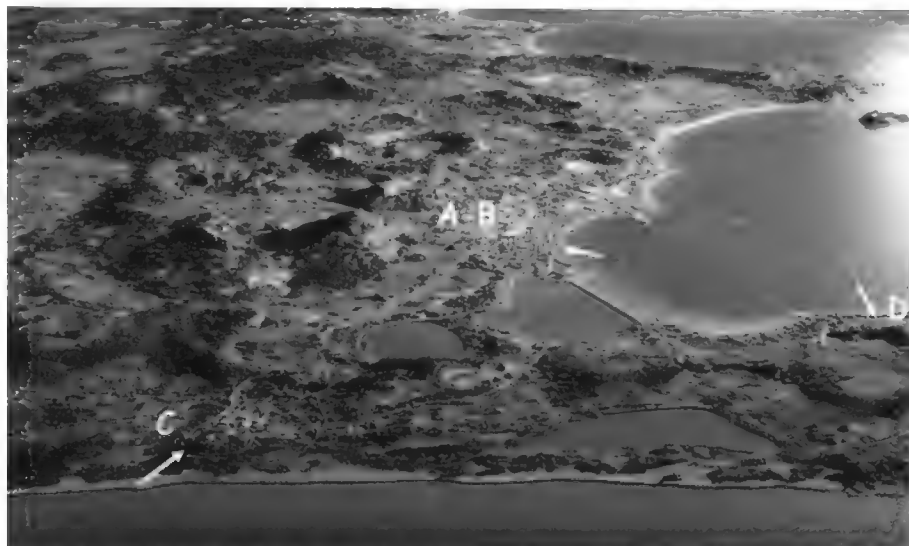
As for other terrestrial forms, large growths of these algae may produce an accumulation of organic matter and locally increased humidity facilitates the settlement and growth of other organisms, such as fungi, mosses and vascular plants. In addition, microorganisms are able to obtain different elements for their metabolism by biosolubilization of the rock material. Such microbial biosolubilization involves the production of organic and inorganic acids by the metabolic activity of algae, lichens, fungi and bacteria (5,6).

A wide research program on the archaeological areas in Campania, a region in South Italy, has revealed a rich cultural heritage of monuments built in volcanic rocks. One of the lithic materials most commonly used since ancient times in this region is the Campanian Ignimbrite, a volcanoclastic rock that is connected with the main eruption that took place in Campania 33.000 y.b.p. in the Phlegraean Fields, a volcanic area in the north-west of the city of Naples. The lithification process of the Campanian Ignimbrite led to the formation of different products, among those piperno and tuff, with similar chemical composition represented by SiO<sub>2</sub>, TiO<sub>2</sub>, CaO, FeO, BaO, K<sub>2</sub>O (7). Tuff and piperno are the different *faces* of the same rock and consist of consolidated volcanic ash ejected from vents during a volcanic eruption (7). These kinds of rocks have a high porosity and a high water capacity, characteristics making them optimal substrates for the colonization and formation of biofilms.

The present work deals with the endolithic communities colonizing piperno and tuff rocks of several monuments in the Phlegraean Fields. Both taxonomic identification of bioincrustating organisms and examination of substrata on which they grow are discussed.

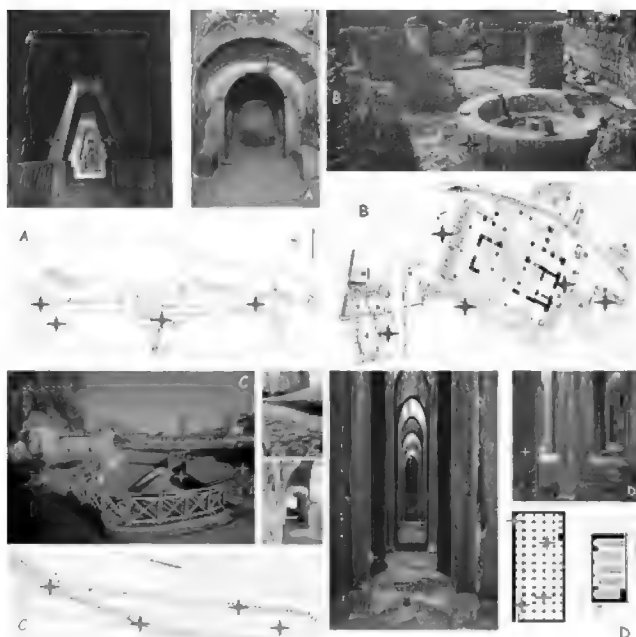
## 2 Materials and Methods

**2.1 Sites description and sampling.** Samples of microbial communities developing as biofilms were collected from the following monuments in the Phlegraean Fields (Fig 1):



**Fig. 1:** Location of the four investigated monuments in the Phlegraean Fields. A: The Cave of the Sibyl; B: The Temple of Apollo; C: The *Stadium of Antoninus Pius*; D: The *Piscina Mirabilis*

**THE CAVE OF THE SIBYL (Site A)** In the ancient city of Cuma, it is a straight tunnel, 131.2 m long, trapezoidal in section, dug in tuff, originally used by Ancient Greeks and Romans as a military station, and later as a tank. For its impressive shape and suggestive light effects, it was identified with the cave of the Sibyl of Cuma, also mentioned in Virgil's Aeneid (Fig 2A).



**Fig. 2:** A: The Cave of the Sybil; B: The temple of Apollo; C: The *Stadium of Antoninus Pius*; D: The *Piscina Mirabilis*. The plan of each monument is reported. Small stars indicate sampling points

**THE TEMPLE OF APOLLO (Site B)** Located on the lower terrace of the Acropolis of Cuma, it was built in the Greek and Samnite Age, then rebuilt and expanded by the Romans in the Augustan Age with the addition of a porch on the east side. The only remain of the original building is the podium in blocks of tuff (Fig. 2B).

**THE STADIUM OF ANTONINUS PIUS (Site C)** The *Stadium* is located in the city of Pozzuoli and is one of the most important stadiums of the antiquity. It has a rectangular plan with one of the short sides curved and the other slightly curvilinear; the latter, reserved for the “departure” of athletes, has a monumental portal. The complex was built entirely in piperno and tuff (Fig. 2C).

**THE PISCINA MIRABILIS (Site D)** It was a Roman tank collecting the water coming from Naples through an aqueduct. It had also functioned to supply water to the Roman navy. Entirely excavated in a yellow tuff, it has a rectangular plan, 25 x 72 m, 15 m high, and a capacity of 12.600 cubic meters of water (Fig. 2D).

Climate conditions, typical of a Mediterranean area, are the same in the four monuments.

**2.2 Microscopy.** Optical microscopy was used for observations of microorganisms (Nikon Eclipse E800). SEM was also employed in order to examine in a more detailed way the morphology of microbial populations as well as the

relation between the microbial growth and the mineral substrate. In this regard, small chips of biofilms, after critical point drying, were coated with gold in an Emitech k550 Sputter Coater and examined and photographed by a Philips EM 208S. The chemical elements were detected using a microanalysis system (ZAFPB).

**2.3 Molecular analysis.** Identification of microbic components of biofilms was also made by a molecular technique. DNA was extracted using the procedure described in Doyle & Doyle (8). PCR amplification was performed with an estimated 10 ng of extracted DNA. For cyanobacteria, the primer set 16S rRNA (9) was used; for algae and mosses, the primer set 18S rRNA previously detailed by Huss *et al.* was used (10). PCR reaction was performed in 50 µl containing 5 µl of 10 x PCR buffer, 100 mM of each deoxynucleotide triphosphate, magnesium chloride (2.5 mM) primer (0.5 mM) and 1 U of Taq Polymerase (Quiagen, Hilden, Germany). The PCR program consisted in an initial denaturation at 95 °C for 4 min and 30 cycles including 1 min of denaturation at 94 °C, 45 s of annealing at 56 °C and 2 min extension at 72 °C. A final extension of 7 min at 72 °C followed by cooling at 4 °C terminated the PCR program. PCR products were controlled on a 1% agarose gel and their concentration was evaluated in comparison with 2 µl of smart ladder (Fermentas).

To obtain detailed identification data on members of bacteria, algae and mosses communities, clone libraries containing 16S and 18S rDNA fragments were created. An aliquot of purified PCR products were ligated into the pGEM-T easy Vector system (Promega, Vienna, Austria), following the manufacturer's instructions. The ligation products were then transformed into *Escherichia coli* XL Blue TC, which permits the identification of recombinants. Clones were screened on DGGE and sequenced with a 3130 genetic analyses (Applied Biosystems).

DGGE (Denaturing Gradient Gel Electrophoresis) analyses were conducted following the protocol of Diez *et al.* (11). Products from environmental samples were applied to individual lanes in the gel. The following electrophoresis conditions were 16 h at 100V. DGGE bands were sequenced after excision from gel and reamplification. The sequences obtained from DGGE bands were compared with available sequences in the database of GeneBank.

### 3 Results and Discussions

Samples from all sites showed taxonomic homogeneity in the microbial composition of biofilms. Cyanobacteria and algae were particularly abundant, with percentage ratios depending on the sites. Mosses were also abundant in all the samples. A total of nineteen taxa were determined, specifically six Cyanobacteria, seven Chlorophyta, one Bacillariophyta, one Rodophyta, and four mosses (Table 1).

**Table 1:** Taxa determined in the four investigated monuments

	<b>Antoninus Pius Stadium</b>	<b>Piscina Mirabilis</b>	<b>Sybil's Cave</b>	<b>Temple of Apollo</b>
<b>Cyanobacteria</b>				
<i>Aphanothece</i> sp.	+	+	+	+
<i>Chroococcus</i> sp.	+	+	+	+
<i>Leptolyngbya</i> sp.	+	+	+	+
<i>Nostoc commune</i>	+	+	+	+
<i>Oscillatoria</i> sp.	+	+	+	+
<b>Algae</b>				
<i>Chlorella</i> sp.	+		+	+
<i>Chlamydomonas reinhardtii</i>	+			+
<i>Cyanidium</i> sp.		+	+	
<i>Pinnularia obscura</i>		+	+	
<i>Pseudococcomyxa</i> sp.	+			+
<i>Scenedesmus</i> sp.		+		
<i>Scotiellopsis terrestris</i>	+	+	+	+
<i>Stichococcus mirabilis</i>	+			+
<i>Stichococcus</i> sp.	+		+	+
<b>Mosses</b>				
<i>Brachythecium salebrosum</i>	+	+	+	+
<i>Bryum</i> sp.	+	+	+	+
<i>Hypnum lindbergii</i>	+	+	+	+
<i>Pottia truncata</i>	+	+	+	+





Among cyanobacteria, we identified *Aphanothece* sp., *Chroococcus* sp., *Leptolyngbya* sp., *Nostoc commune*, *Oscillatoria* sp. and *Synechococcus* sp. with their maximum occurrence in the Cave of the Sibyl and the *Piscina Mirabilis*. These cyanobacteria occurred in all sites, in particular on the tuff rock, as shown by bands migration during the DGGE analysis. Specific environmental conditions, such as penumbra, high values of humidity and occurrence of brittle rocks, seemed to cause the high growth of cyanobacteria.

Among green algae, we found *Chlamydomonas reinhardtii*, *Chlorella* sp., *Pseudococcomyxa* sp., *Scenedesmus* sp., *Scotiellopsis terrestris*, *Stichococcus mirabilis* and *Stichococcus* sp., with *Scotiellopsis terrestris* resulting the most abundant species, as shown by the relative 18S rRNA gene profile band (Fig. 3A). In the *Piscina Mirabilis* and the Cave of the Sibyl the Bacillariophyta *Pinnularia obscura* and the Rhodophyta *Cyanidium* sp. were also found (Fig. 3B). *Cyanidium* sp. grows in extreme environmental conditions, high temperature, acidic soil and may live in eterotrophic conditions, the last characteristic justifying its growth in the examined sites. Occurrence of this Rhodophyta in the Sybil cave and other caves has been previously reported (12). Similarly to *Cyanidium*, *Pinnularia obscura* is able to live in acidic and thermal environments and was also reported for areas of Phregean Fields where extreme environmental conditions occur (12,13).

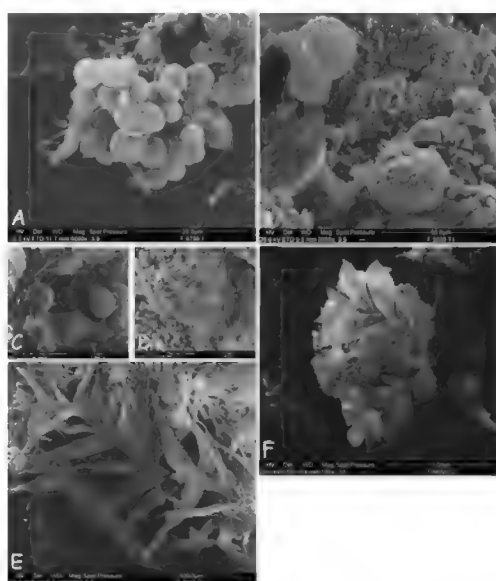
Mosses *Brachythecium* sp., *Bryum* sp., *Hypnum lindbergii* and *Pottia truncata* were found in all samples. They were particularly abundant in the *Stadium of Antoninus Pius* and Temple of Apollo, sites more exposed to the sun and atmospheric agents. We noted that the mosses caused the detachment of small substrate fragments, especially on the piperno steps in the *Stadium of Antoninus Pius*.

**Fig. 3:** Some exemplificative bands obtained for algae. Lane A: band 1 *Chlorella* sp., band 2 *Pseudococcomyxa* sp., band 3 *Scenedesmus* sp., band 4 *Scotiellopsis terrestris*. Lane B: band 5 *Cyanidium* sp., band 6 *Pinnularia obscura*

Observation of SEM micrographs of biofilms confirms the interaction between biotic components and the substrate forming a complex association including, besides cyanobacteria, algae and mosses, also coccoid bacteria (Fig. 4). SEM microanalysis of biofilms allowed the identification of various inorganic elements, i.e., Si, Ca, S and Al. These elements presumably derive from inorganic substrata throughout the lithification process of the Campanian Ignimbrite cited above (7). The diversity of species found in the four monuments is in accordance with results of similar studies on biofilms of other investigated historical monuments (14).

Among the techniques employed for the elimination of the microorganisms without altering the chemical nature of the substrate on which they develop, we have obtained interesting preliminary results by using biopesticides or adopting a technique based on the use of microwaves.

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**Fig.4:** Exemplificative SEM micrographs. A-D) cyanobacteria and algae; E, F) mosses

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# INVASIVE PLANTS ON A MOSAIC OF A ROMAN THERMAL BATH: A FLORISTIC AND ECOLOGICAL PRELIMINARY SURVEY

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## Abstract

The Roman Thermal Baths of via Terracina in Naples, Italy, is an archaeological area of II Century BC, built on several levels. It is constituted by two principal areas (*frigidarium* and *apodyterium*), and several environments (*corridor* and *tabernae*), which were later added to the early structures. The better conserved area of the site is the *frigidarium*, with a large patterned bichromatic mosaic that adorn the floor; this small area is characterized by some homogeneous conditions: the floor is even exposed to the sunlight in the summer and to the rainfall during autumn and winter. Water dries out quickly, so it is possible to find a high level of moisture only in the shade under the walls surrounding the floor. Plants grow extensively along the mosaic floor of the *frigidarium*, enlarging with their roots the already existing cracks, and irremediably damaging the mosaic year after year. The mosaic already presents areas no longer covered by *tesserae*, destined to be enlarged if a new restoration won't be carried out as soon as possible. A floristic survey was carried out in the Spring and the Summer of 2006 and 2007. Plants growing over the entire site were sampled and identified according to Italian and European floras. The presence of each species and its frequency in the area have been listed. Moreover, a first attempt toward the identification of their strategies of colonization has been carried out.

Therophytes represent the most abundant (60 %) group of plants occurring in the site, followed by the hemicryptophytes (33%), while geophytes, camephytes and phanerophytes were less diffused, reaching all together the 6 %. The weeds identified on the mosaic were also analysed for their strategies of competition. Most of them presented intermediate mechanisms of competition for resources, and could be defined as stress tolerant-competitive species.

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**Keywords:** Archaeology, Mosaic, Invasive plants, Biodeterioration

## Introduction

Weeds can be defined as unwanted plants that thrive in habitats disturbed by man. Since ancient times human activities such as commerce, movements of armies, geographic discoveries, and the industrial revolution have extensively mixed the flora of similar bioclimatic regions through both deliberate and accidental introduction of species. For example, Italy has 6711 species as native vascular plants and 782 introduced species [1]. A fundamental basis for a sound weed management is to know: a) the species present and the level of infestation; b) biology and ecology of the prevalent species. Archaeological sites, historical buildings and ancient ruins are suitable habitats for weeds, which can cause serious damages, particularly weakening and cracking building walls and floors. Mosaics are composite matrices made up by small pieces of cut stones, glass or other materials (generically called *tesserae*), inserted in a base of mortar or adhesive all and floor mosaics are common in Roman archeological sites, and their "in situ" protection requires particular attention. Damage to mosaics consists in the breakage related to the detachment of *tesserae* from the matrix, and plants growing in the interstices of *tesserae* is one of the most important causes of mosaic deterioration, leading to the final detachment of *tesserae*.

This paper describes the flora infesting a Roman Thermal Bath of the II century A.D. located in the archaeological complex of via Terracina in Naples, trying also to attempt a preliminary classification of the invasive plants according to CSR theory [2]. The aim is to build up the corpus of knowledge required for a weed control strategy based on an environmental safe method of control.

## 1. Materials and methods

### 1.1. Floristic surveys.

The floristic surveys were carried out in the Spring and the Summer of 2006 and 2007. Plants growing over the entire site were sampled and identified according to Italian and European floras [3, 4, 5]. The mosaic floor area, located in the *frigidarium*, was investigated in detail: all the species present in the interstices of the mosaic in the *frigidarium* were collected and voucher specimens were prepared. The floristic list of plants collected from the mosaic floor of the *frigidarium* is alphabetically reported in table 2. Plant names are reported according to Conti *et al.* [6]

## Results

### Description of the site

The Roman Thermal Baths of via Terracina in Naples is an archaeological area of II century A.D., built on several levels. It is constituted by two principal areas (*frigidarium* and *apodyterium*), and several environments (*corridor* and *tabernae*), which were later added to the early structures. The state of conservation of this site is not optimal: invasive vegetation is spread everywhere, covering walls and paths. A preliminary examination of invasive flora in the site evidenced that the dominant weeds over the entire area were: *Erigeron canadensis* L., *Lolium rigidum* Gaudin subsp. *rigidum*, *Parietaria judaica* L., *Silene latifolia* Poir. subsp. *alba* (Mill.) Greuter et Bourdet, *Stellaria media* Vill. s.l., *Urtica membranacea* Poir. ex Savigny. These plants were selected for the allelopathic tests carried out in the course of this study.

The better conserved area of the site is the *frigidarium*, with a large patterned bichromatic mosaic that adorn the floor. The mosaic consists of black and white *tesserae* which occupy a rectangular area. Around the perimeter of the mosaic black tesserae are placed together to form a geometric frame, which delimitates a central area containing different designs of sea monsters and animals: an hippocampus, Poseidon and a dragon, a panther, and Poseidon riding a bull (Fig. 1). The mosaic was restored about thirty years ago and it is in relatively good conditions, but it is cracking in several spots, due to the invasive growth of numerous weeds between the *tesserae* of the mosaic.



**Fig. 1** - The mosaic of Thermal Bath *frigidarium*

### Flora infesting the *frigidarium* in the thermal baths.

The *frigidarium*, placed in the centre of the thermal baths, is mainly a shadowless and dry ambient. The floor is slightly inclined, so it allows rain water to flow down into the drain-pipe quickly. The great central mosaic, many times restored in the past, is infested by numerous species of herbaceous plants (Fig. 1), which germinate into the tight spaces between the mosaic *tesserae* or on the soil covering some spots of the mosaic. The weeds growing on the *frigidarium* mosaic have been identified according to Pignatti [3] and Tutin *et al.* [3, 4]. The presence of each species, and its frequency in the area have been listed. The acronyms used for this purpose are: C = common; CC = very common; R =, rare RR = very rare. The list of the species (Tab. 1) shows the complete nomenclature, according to CONTI *et al.* [6], the frequency, the "life-form" categories according to Raunkiaer [7], modified by Pignatti [3] and the biological strategies, as reported by Grime *et al.* [2]. For some of the species occurring in the *frigidarium* and not reported by Grime *et al.* [2], the identification of the biological strategies was carried out through a general ecological comparison with the entities included in Grime *et al.* [2]. The entities marked with the acronym w.i. are those for what the identification of biological strategies was not possible, due to a lack of ecological data.

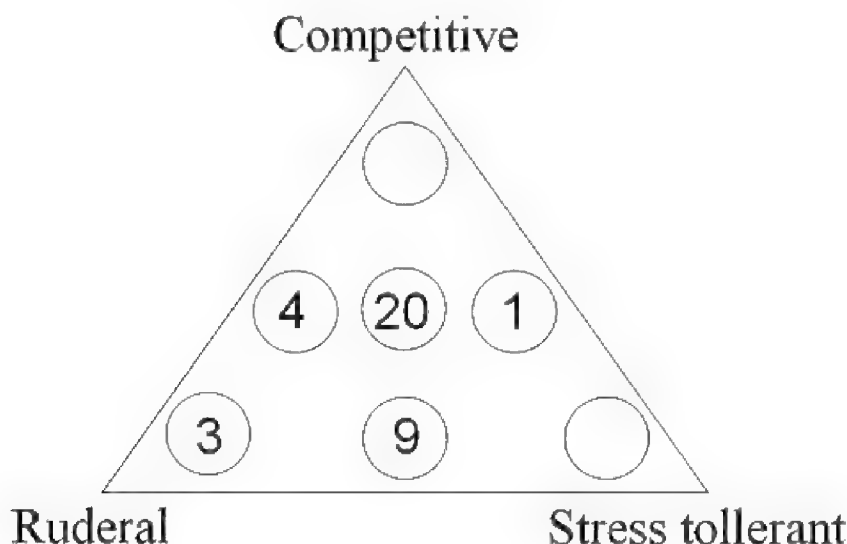
Therophytes represent the most abundant (60 %) group of plants occurring in the site, followed by the hemicryptophytes (33 %), while geophytes, camephytes and phanerophytes were less diffused, reaching all together the 6 %.

The mosaic floor can be considered as a resource-deficient habitat, which endures also periodic stresses represented by the annual, manual weeding of the plants invading the mosaic. Many entities growing in the interstices of the



mosaics can be considered as intermediate species which show a mixed biological strategy, encompassing Competitive, Ruderal and Stress tolerant characters. (Fig. 2). A modest number of species (8 %) has been found to belong to one of the three primary strategies (Ruderal), whereas the group of Stress tolerant and Competitive was represented by a smaller percentage (3 %).

Plants grow extensively along the mosaic floor of the *frigidarium*, enlarging with their roots the already existing cracks, irremediably damaging the mosaic year after year. The mosaic already presents areas no longer covered by *tesserae*, destined to be enlarged if a new restoration won't be carried out as soon as possible.



**Fig. 2** - Classification of plants growing on the mosaic of *frigidarium*, according to CSR theory (Grime *et al.*, 1988).

Competitive – tending to maximize resource capture and vegetative growth

Ruderal – tending to curtail vegetative growth and to maximize seed production

Stress tolerant – tending to conserve resource captured. Small growth rate and slight morphogenetic response.

### Discussion

Generally, the floristic surveys carried out in archaeological sites regard large areas Caneva *et al.* [8], not homogeneous for what may concern building materials, exposure to the air and to the sunlight, moisture: different microclimates can be found in the same area.

On the contrary, this work considers a small area, the *frigidarium* in the Roman thermal baths in Naples, characterized by some homogeneous conditions: the floor is even, exposed to the sunlight in the summer and to the rainfall during autumn and winter. Water dries out quickly, so it is possible to find a high level of moisture only in the shade under the walls surrounding the floor.

The floristic analysis has evidenced that the flora growing on the mosaic is largely resistant to alien plant invasion, as already shown in other archaeological sites [9].

In the microclimatic conditions occurring in the Thermal Bath of via Terracina, the plant species found are mostly therophytes and hemicryptophytes. The soil particles filling the spaces between the tesserae of the mosaic take up water in a fast way, allowing the rapid colonization by these kind of plants. Control measures of weed growth in the thermal bath of Terracina include the manual removing of the weeds that shade the mosaic, but this treatment is only superficial and is carried out only once a year, to avoid damaging the mosaic. This managing technique also contributes to the successful colonization of the mosaic by therophytes and hemicryptophytes. The first ones have short lives but produce a high number of seeds, which remains in the soil, whereas hemicryptophytes tend to have underground storage organs which are very difficult to remove without damaging the mosaic.

Controlling invading plant plays a key role in the conservation of a mosaic. But, it is first necessary a profound knowledge of ecological and biological features of the invasive organisms to find a correct approach to their strategy control.

**Tab. 1** - List of invasive plants growing on the mosaic floor of thermal bath.**Strategies:** Stress tolerant ST, Ruderal R, Competitive – C.**Abundance:** C = common; CC = very common; R = rare; RR = very rare.**Biological form:** Ch = Chamaephyte: any perennial plant whose winter buds are within 30 cm of the soil surface; G = Geophyte: a perennial plant that is deeply embedded in the soil substrate; H = Hemicytotype: a plant having buds at the soil surface; P = Phanerophyte: a perennial tree or shrub with dormant buds borne on aerial shoots within more than 30 cm of the soil surface; T = Therophyte: an annual plant whose seed is the only over wintering structure.

Species	Strategies	Abundance	Biological form
<i>Anagallis arvensis</i> L. s.l.	ST-R	R	T rept
<i>Bromus madritensis</i> L.	C-ST-R	C	T er
<i>Calamintha nepeta</i> (L.) Savi s.l.	C-ST-R	C	H scap
<i>Carex flacca</i> Schreb. s.l.	w.i.	RR	G rhiz
<i>Catapodium rigidum</i> (L.) C.E. Hubb. ex Dony s.l.	ST-R	C	T er
<i>Cerastium brachypetalum</i> Desp. ex Pers. subsp. <i>brachypetalum</i>	ST-R	C	T er
<i>Crepis neglecta</i> L.	C-ST-R	C	T er
<i>Crepis setosa</i> Haller fil.	C-ST-R	R	T er
<i>Cynodon dactylon</i> (L.) Pers.	ST-R	CC	H rept
<i>Dactylis glomerata</i> L. subsp. <i>glomerata</i>	C-ST-R	CC	H scap
<i>Daucus carota</i> L. subsp. <i>carota</i>	C-ST-R	CC	T er
<i>Digitaria sanguinalis</i> (L.) Scop. s.l.	w.i.	CC	T er
<i>Erigeron canadensis</i> L.	C-ST-R	CC	T er
<i>Fumaria capreolata</i> L. s.l.	R	R	T er
<i>Galium aparine</i> L.	C-R	C	T er
<i>Geranium molle</i> L.	ST-R	R	T er
<i>Heliotropium europaeum</i> L.	w.i.	CC	T er
<i>Hypericum perforatum</i> L.	ST-R	CC	H scap
<i>Hypochaeris achyrophorus</i> L.	w.i.	R	T er
<i>Hypochaeris radicata</i> L.	ST-R	RR	H ros
<i>Lamium purpureum</i> L.	C-ST-R	RR	T er
<i>Lolium rigidum</i> Gaudin subsp. <i>rigidum</i>	C-ST-R	CC	T er
<i>Medicago lupulina</i> L.	C-ST-R	R	T rept
<i>Medicago murex</i> Willd.	w.i.	R	T er
<i>Melilotus albus</i> Medik.	w.i.	R	T er
<i>Micromeria graeca</i> (L.) Benth. ex Reichb. subsp. <i>graeca</i>	C-ST-R	C	Ch suff
<i>Oxalis corniculata</i> L.	C-ST-R	R	H rept
<i>Parietaria judaica</i> L.	C-ST-R	CC	H scap
<i>Picris hieracioides</i> L. s.l.	C-ST-R	CC	H scap
<i>Piptatherum miliaceum</i> (L.) Coss. subsp. <i>miliaceum</i>	C-ST-R	CC	H caesp
<i>Plantago lanceolata</i> L.	C-ST-R	CC	H scap
<i>Poa annua</i> L.	C-ST-R	C	T er
<i>Reichardia picroides</i> (L.) Roth	C-ST-R	C	H scap
<i>Rostraria cristata</i> (L.) Tzvelev subsp. <i>cristata</i>	w.i.	C	T er
<i>Rumex pulcher</i> L. s.l.	C-ST-R	R	H scap
<i>Sagina apetala</i> Ard. subsp. <i>apetala</i>	w.i.	R	T er
<i>Senecio vulgaris</i> L.	R	R	T er
<i>Setaria verticillata</i> (L.) P. Beauv.	C-R	C	T er
<i>Silene latifolia</i> Poir. subsp. <i>alba</i> (Mill.) Greuter et Burdet	ST-R	C	H bien
<i>Sonchus asper</i> (L.) Hill subsp. <i>asper</i>	C-R	C	H scap
<i>Stellaria media</i> (L.) Vill. s.l.	R	C	T rept
<i>Symphyotrichum squamatum</i> (Spreng.) G.L. Nesom	w.i.	R	T er
<i>Thuja occidentalis</i> L.	C-ST	RR	P scap
<i>Trifolium pratense</i> L. subsp. <i>pratense</i>	C-ST-R	C	H scap
<i>Urtica membranacea</i> Poir. ex Savigny	C-R	C	T er
<i>Verbascum sinuatum</i> L.	w.i.	C	H bien
<i>Veronica arvensis</i> L.	ST-R	RR	T er
<i>Vicia sativa</i> L. subsp. <i>nigra</i> (L.) Ehrh.	C-ST-R	R	T er

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## CHARACTERIZATION OF THE ALGAL FLORA GROWING ON FRESCOES IN THE ARCHEOLOGICAL SITE OF POMPEI.

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Cyanobacteria and algae can grow on a wide range of substrates, including works of art, contributing to their decay. A preliminary survey carried out during 2007 has evidenced that in more than 50% of the houses of the archeological site of Pompei the frescoes are partially covered by algal populations, generally associated to bacteria and fungi, to form thick biofilms, whose control is often troublesome. It is probably impossible to find a single strategy useful to achieve this scope, and the identification of the algal strains occurring in the biofilms is of pivotal importance to mitigate their negative impact on frescoes. In this respect, a survey of algal flora growing on Pompei frescoes has been attempted, with the aim of isolating a large number of cyanobacteria and algae to be maintained in laboratory cultures. In a first approach, samples have been collected from houses. The observation at light microscope revealed that the algal flora was composed by Cyanobacteria and Chlorophyta. Different combinations of fungicidal and antibiotic compounds were used to obtain monoalgal strains, whereas Cyanobacteria were isolated after a treatment with a mixture of nystatin and cycloheximide. The isolated are maintained in the algal collection of University of Naples. The research will be progressively extended to other Pompei houses, with the aim of creating an algal bank of algal isolates. Each strain will be classified on the basis of morphological and molecular data. Moreover the main ecophysiological features will be assessed to identify the best conditions to limitate their diffusion. The possibility of using water extract from higher plants and other algae to inhibit the algal growth will also taken into account.

## PALAEOENVIRONMENTAL INVESTIGATIONS AT PORTUS, THE LOST PORT CITY OF IMPERIAL ROME

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The ancient port built along the Tyrrhenian coast by Roman Emperor Claudius (1<sup>st</sup> Cent. AD), and modified by Emperor Trajan (2<sup>nd</sup> Cent. AD) was Rome's principal maritime port from the middle of the first century onward and important gateway between Rome and the Mediterranean. Historical sources report that the imperial harbour was excavated both in terra firma and in lagoons. The harbour town named Portus developed together with the port itself and expanded in the following centuries. The remains of the port and of the town raised in the close vicinity are 3.5 km away from the present coastline, in the Tiber delta.

The current multidisciplinary research about the area of the ancient port has involved several disciplines such as archaeology, geomorphology, palynology, archaeobotany, ostracodology, and geochemistry. The objective of this study was to reconstruct both the plant cultural landscape and the water environment in the harbour basins. The environmental changes are linked to natural changes, to the harbour human management and to the development of Portus, the harbour town.

The "Soprintendenza per i Beni Archeologici di Ostia" carried out a series of deep corings in the area of the ancient port to reconstruct the shape and the environment of the Tiber delta dating back to the Roman period. Sediment, ostracod, mollusc, pollen, microcharcoal, plant macroremains and radiocarbon analyses were carried out on the marine silt sediments recovered in the cores PT S5 and PT S13, down to the depth of 11.22 m and 6.76 m respectively, drilled in the area of the port.

The chronological framing of the records are based on stratigraphical criteria, radiocarbon dates, historical data and pottery fragments.

Pollen, plant macroremains, and ostracod assemblages indicate that the two cores record different periods of time. One core shows the first phases of the harbor activities, with a rather preserved plant landscape typical of a coastal environment. The other core records a stronger human impact related to the presence of the port town.



## ON A NEANDERTAL TRAIL: COMMERCIAL ASPECTS OF AN EXTINCT POPULATION

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### Abstract:

Among the riches of Croatian heritage are several Middle Paleolithic sites located in both the coastal and inland regions of Croatia. Sites such as Krapina and Vindija where the Neandertal remains were found are well known among scientists interested in human evolution and prehistoric archaeology. At several other sites, Mousterian tools and other items document Neandertal presence and habitation. Paleoanthropological, archaeological, zooarchaeological and lately, genetic studies have allowed an interesting insight into biocultural properties and variation (both populational and temporal) of these interesting humans. New research is providing an interesting insight into Neandertal adaptation to different local environmental and ecological zones (namely comparisons between the inland site of Vindija and Mujina Pećina on the coast). Ongoing research at various sites and regions will allow us to learn more about contact zones and patterns during the Late Pleistocene.

However interesting and scientifically important these results are, one of the often neglected aspects and potentials of archaeological research is in public presentation of results and sites. Results obtained by various scientific analyses need to be transferred into an easily understandable form for non-scientists. This will add to the overall understanding of local community on the importance of the sites and make them embrace them as a part of their intellectual and cultural heritage. Furthermore, an investment in cultural preservation and presentation of these sites as a part of tourist route is of crucial importance. Cultural tourism has long been a keyword of modern economical strategy of many countries and proved to be a good investment.

Recently, a collaborative project under the title "The Neandertal Trail" has been started. Its main aim is the inclusion of the aforementioned "Neandertal" sites in the local tourist offer. In fact, the project is an original thematic unit which aims at unifying and evaluating in terms of cultural tourism the archaeological heritage pertaining to Neandertals in Croatia, through the creation of a cultural route with all elements essential in the development of a comprehensive cultural-tourist product. The target audience in the narrow sense are tourists with a specific interest in archaeology and archaeological heritage, and in the wider sense, cultural tourists in general. Great care within the project has been given to the educational role, with the intention to promote the stations on the Trail as a logical choice for the sites in learning about the earliest prehistory and human evolution. An important role in the implementation of the project is reserved for the local community, but first it is necessary to make them familiar with and interested in the project, which is done in various ways.

Presupposed positive financial effects will be used in part for further research and scientific valorization, but also for the physical protection of the sites themselves.

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**Keywords:** Neandertals, cultural tourism, archaeological heritage, Croatia

### 1. INTRODUCTION

Croatia is a small, but geographically and culturally very diverse country whose national income is heavily dependent on tourism. Today, more than before, the tourism is changing and becoming increasingly diverse and interest-oriented. Cultural heritage and archaeological sites in particular are becoming more of a focus of numerous foreign visitors. Many countries have long realized that the archaeological sites are of particular interest (e.g. Italy, Greece, Egypt, to name a few), while others (e.g. Turkey) are becoming more and more aware of this and are successfully developing this particular brand of tourism. Some of the sites in Croatia, like the palace of the Emperor Diocletian in today's city of Split in Dalmatia, the Roman amphitheatre in the town of Pula in Istria, medieval villages of inland Istria, or the Old town of Dubrovnik in the southernmost part of our country are worldwide known destinations for hundreds of thousands of visitors each year. Many other sites and monuments of Roman, Greek, or medieval period are also visited in great numbers and local authorities are doing their best to include these sites in the tourist offer. However, Croatia is quite rich in archaeological sites of much older periods. These are, sadly, very seldom included in various tourist packages offered to potential visitors. Archaeology and tourism have recently been a subject of a large exhibition at the Archaeological Museum in Zagreb, and a publication of the same name, drawing attention to this particular brand of tourism<sup>1</sup>. A particular place within the exhibition was dedicated to the sites from a specific prehistoric period – the Middle Paleolithic (or the middle part of the Old Stone Age) and its European makers – the Neandertals. Neandertals are often on the cover of popular scientific journals such as National Geographic, Geo, Archaeology etc. and popular TV programmes are increasingly focusing on various aspects of their biological and cultural heritage. Therefore, we believe that the inclusion of these older, Middle Paleolithic, Croatian sites has a great potential for tourism. Recently, a project aimed at the development of a cultural route dedicated to the Neandertal habitation of the territory of the Republic of Croatia was started under the auspices of the Archaeological Museum in Zagreb.<sup>2</sup> The project will include numerous collaborators from the fields of archaeology, heritage management, and tourism. Its main aim is presentation of rich cultural heritage of these prehistoric inhabitants of Croatia and of the results of scientific investigations to general public, Croatian and

foreign alike, thus allowing a beneficial integration of archaeology and tourism. Preservation and protection of the sites and their preparation for the inclusion in the tourist offer is of interest of both scientists and local community. Some of these sites, namely the Hušnjakovo Hill in Krapina, and lately to a smaller extent, the Vindija cave, both in the Hrvatsko Zagorje region, have been recognized as the sites interesting for visitors. Soon a new museum dedicated to human evolution will be opened near the original site at Krapina, replacing the now quite outdated smaller museum nearby (Fig. 1). On our last visit to the Vindija cave we were happy to see a life-sized statue of a „Neandertal“ close to the site, clearly visible from the road. However, much remains to be done before this site can be properly presented to the public. There are also other sites that have yielded cultural remains of the Mousterian industry, a Middle Palaeolithic culture that is, at least in Europe, solely associated with Neandertals. These are situated in both continental and Adriatic parts of Croatia, thus allowing us to develop an organized route for all interested in such cultural experience.

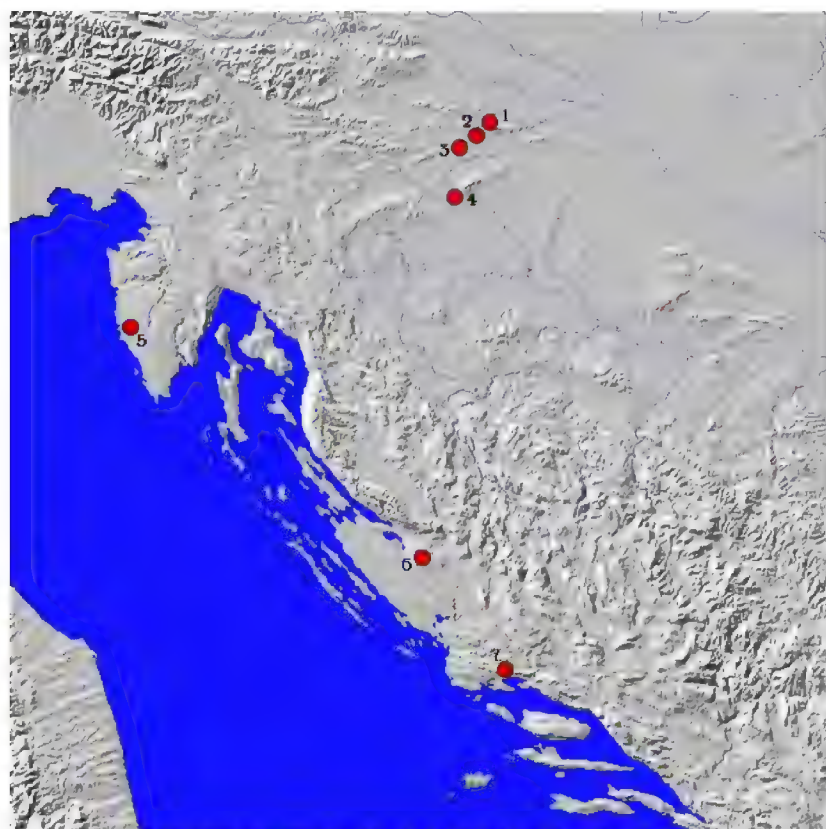


**Figure 1** - Work in progress on the building of the new museum in Krapina

## **2. THE NEANDERTAL TRAIL**

The backbone of the project and the entire Trail consists of the sites where the skeletal remains of the Neandertals or the Mousterian artefacts have been found. These include: Krapina-Hušnjakovo Hill, the Vindija cave, the Velika Pećina cave near Goranec, the Veternica cave, open-air sites in the Ravni Kotari region, the Velika Pećina cave in Kličevica, the Romualdova Pećina cave, the Mujina Pećina cave<sup>3</sup>. In terms of geography, the Neandertal Trail covers both continental and Adriatic parts of Croatia (Fig. 2), and a look at the distribution of the sites on the map reveals an interesting trait: all the so far known sites are situated roughly on the route of the highway connecting Varaždin and Krapina (that is, the Croatian border with Slovenia and Hungary) with Split, with the exception of Romualdova Pećina, which is situated in Istria. This fact lends an important cohesive quality to the route.

Tourists can start their journey at any spot of the imagined route: for instance, at the indisputably most famous archaeological site with Neandertal finds in Croatia – Krapina, at the same time the first point of the route for those coming from Austria and Slovenia.



**Figure 2** - Map of Croatia with the stations on the Trail: 1. Vindija, 2. Velika Pećina, 3. Krapina, 4. Veternica, 5. Romualdova Pećina, 6. Velika Pećina u Kličevici, 7. Mujina Pećina.

Hušnjakovo Hill in Krapina as well as the nearby Vindija cave are the only sites in Croatia that yielded skeletal remains of the Neandertals. At the site at Krapina the remains of about 70 different individuals, dated to approximately 130,000 years BP, have been found, making this the largest Neandertal site according to the number of individuals anywhere in the world. This allowed numerous scientific analyses to reveal important data on their anatomical details, behavior and individual variation. The Neandertal remains found at the site of Vindija (Fig. 3) represent one of the youngest dated Neandertal populations in this part of Europe. Dated to about 32,000 years ago, these Neandertals were living at the time when the earliest groups of anatomically modern humans were already present at some sites in Europe. Therefore the archaeological analyses of finds from Vindija are of crucial importance to the current and ongoing debate on the fate of Neandertals and their relationship to the genesis of early modern Europeans<sup>4</sup>.



**Figure 3** - Vindija



The stratigraphy of the Velika Pećina cave (Fig. 4), which lies between Vindija and Krapina, is also in excellent state and offers superb prospects for future archaeological excavations and hopefully also important discoveries. As in the case of Vindija, this cave also has to be protected before the organized tourist visits to this site take place.



**Figure 4 - Velika Pećina**

The Veternica cave (Fig. 5) is situated on the slopes of the Medvednica mountain in the Zagreb suburbs. It is one of the largest cave complexes in Croatia, reaching about 7100 meters in total length. For many years now, a part of the cave is open to organized tourist visits, while the more distant and harder to reach parts of the complex can be visited by speleologists. Needless to say, the cave is also a part of the natural heritage and interesting not only for the cultural traces of Neandertal habitation, but also for its natural beauty.



**Figure 5 - Veternica**



The area of Ravni Kotari in the hinterland of Zadar revealed a number of finds and sites that prove this region was long ago visited by Neandertals. Unlike in the case of the aforementioned sites in the continental Croatia, these are open-air sites. However, not too far from these is the site of Velika Pećina in Kličevica. Test excavations at this cave thus far yielded cultural remains of Neandertal habitation, and an organized excavation of the site will start very soon, thus creating the necessary preconditions for including this promising site as an attractive station on the Neandertal Trail.

The cave of Mujina Pećina in the hinterland of Kaštela and Trogir lies at the end – or the beginning – of the backbone of this route, on an elevated position in the Dalmatian karst. Recent excavations of this site, from where a fantastic view opens to the city of Split and the Kaštela Bay, provided answers to a number of questions regarding habitation, diet and activities of the Neandertals that visited the cave around forty thousand years ago, allowing scientists to compare Neandertal subsistence strategy, culture and behavior to that of their contemporaries in the Continental part of Croatia (namely the Vindija Neandertals).

The other arm of the Trail leads from the continent not to Dalmatia but to Istria, to Romualdova Pećina, which has long been known as an important Palaeolithic site, but only recent excavations have shown that it was used not only by modern humans but also by the Neandertals.

The Neandertal Trail thus consists of eight primary stations<sup>5</sup>, a fact that more than anything reflects the state of research and leaves fully open and realistic – and in fact also desired – possibility that such a situation changes for the better.

To this one can add stations of a secondary character, which relate to other features of interest that are directly connected with the basic subject of the route, such as museums which keep archaeological material connected to the sites.

There are finally tertiary stations, which have no direct topical connections with the Trail, but form a natural and/or inevitable background for the traveler on the Trail, such as accommodation establishments, towns and cities on the route or within reach of the route, as well as natural and other cultural features of interest on the route. The target audience of the project, in the narrow sense, are tourists specifically motivated by archaeology and archaeological heritage. In the wider sense, the target audience consists of cultural tourists in general. Research in the tourism sector in Croatia revealed that although only a relatively small percentage of tourists (10%) list visits to cultural attractions as one of the reasons for their arrival, more than half take part in at least some cultural activities.

While in its integral form the itinerary focuses primarily on foreign tourists, individual stations on the local level primarily focus on local residents. The promotion of the stations through the Neandertal Trail Project helps to actively profile them as attractive destinations for one-day excursions, and it is not without importance that there is a station easily accessible within a short time for anyone anywhere in Croatia, with the sole exception of Eastern Croatia or the southernmost parts around Dubrovnik<sup>6</sup>.

Great care within the project has been given to the educational role, with the intention to promote the stations on the Trail as a logical choice for the sites in learning about the earliest prehistory and human evolution, on the model of positive experience in field teaching and extracurricular activities gained in the case of the Roman period<sup>7</sup>.

### 3. THE FUTURE OF THE TRAIL

The inauguration of the Neandertal Trail is planned for 2010, and one of the central elements of the project will, naturally, be the possibility to travel the route of the Trail. However, this will be only the first step in the development of a living project, which will continually undergo changes, improvements and additions. Among the sites that form the mainstay of the Trail, physical visits will be channeled primarily toward those stations that already meet tourist standards. Above all, this applies to Krapina, Vaternica, Romualdova Pećina and Mujina Pećina.

Until the moment when the remaining parts of the itinerary are fully incorporated as physical stations on the Trail, the route will function as a whole in the virtual sense. A number of elements will be used in the promotion of the itinerary: a book will be published, as well as tourist guides, brochures, leaflets and information maps for the route as a whole and for individual sites. Wide availability to interested public will be ensured via a web page dedicated to the Neandertal Trail. We are currently working on a documentary about the Trail *en bloc*, as well as about individual primary stations. As part of the inauguration, an exhibition will be mounted in the Archaeological Museum in Zagreb, which will present the entire project, and the elements of the display will later be used in the creation of the interpretation centres.

The key thing is that the aforementioned elements that make up the project will regard each and every site as an integral part on the Trail, which will have impact on the perception of distinct sites as building blocks of an integrated whole, i.e. as interconnected destinations.

The travelers' orientation on the Trail will be facilitated by signposts (Fig. 2), which will be placed along public roads (national and county roads, as well as local roads leading to a station). Interpretation boards will be placed on the sites or adjacent to them. In designing and placing the signposts and boards we shall follow the guidelines laid down in the Regulations on tourist and other road markings.

An important role in the implementation of the project is reserved for the local community. Thus our first step is to make them familiar and interested in the project. This can be done in several ways. In the case of Mujina Pećina, lectures and discussions were organized with the Trail as the main topic, and in March 2010 a group visit to the cave is planned for local residents and schoolchildren, with participation of the manager of the archaeological excavation of Mujina Pećina<sup>8</sup>. Before the project is launched similar visits will be organized also for other stations, as a rehearsal of sorts for the time when the Trail is fully operational. The open-air venue in the *Lapidarium* of the Archaeological Museum in Zagreb (the Museum courtyard with the permanent exhibition of the collection of stone monuments) will be used for the promotions of the documentaries about individual stations on the itinerary, on the model of the promotion of the documentary about the Veternica cave (Fig. 3)<sup>9</sup>. Similar activities will be organized in other cities and towns.

As regards tourist visits, joint planning with tourism workers will lead to the creation of programmes of different duration of stay (several-day tours – 3, 5, 7 or 12 days – for remote markets, as well as one-day excursions from larger centres to individual sites). Also, a range of types and categories of accommodation will be put forward, from rural establishments to top hotels; a variety of transport options during the journey; options of linking this cultural tour with various forms of adventure tourism (hiking, cycling, horse-riding) etc. Considering the number of visitors, tourist products will be designed for individual guests as well as for small and large groups.

The concept of the Trail is such that it links thematically a number of areas and regions and, importantly, the planned route partly directs the tourist traffic towards regions that are underdeveloped in terms of tourism (i.e. continental Croatia). The project aims to shape and promote the tourist product of several municipalities, towns, cities and counties that are connected by a joint subject. Together with the secondary and tertiary stations, the thematic route is sufficiently attractive to inspire the tourists to take a break, rest or combined holiday in continental and Adriatic destinations.

Once that the Trail has been established on the national level, the next step will consist in contacting and cooperating with stakeholders in the countries that share the Neandertal heritage. Considering the distribution of Neandertal populations in Europe, there is clearly a promising future for the Neandertal Trail within the framework of the European Cultural Routes<sup>10</sup>.

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<sup>1</sup> See Mihelić (ed.) 2009.

<sup>2</sup> This paper is partly based on the preliminary report in Mihelić 2009b.

<sup>3</sup> See Karavanić & Janković (2008) for an extensive survey of the Neandertal sites in Croatia.

<sup>4</sup> For the importance of this site in the debate on modern human origins see Janković et al. 2006 and references therein.

<sup>5</sup> The term "primary stations" refers to the sites with the finds of Neandertals and their material culture.

<sup>6</sup> Most of the large cities and towns in the country gravitate toward the stations on the Trail: Zagreb, Split, Rijeka, Zadar, Šibenik, Varaždin, Sisak, Karlovac.

<sup>7</sup> As for instance in the case of the Andautonia Archaeological Park in the village of Ščitarjevo near Zagreb (see Nemeth-Ehrlich & Kušan Špalj 2007).

<sup>8</sup> Prof. Ivor Karavanić from the Department of Archaeology of the Faculty of Philosophy of the University of Zagreb. The excavations took place between 1996 and 2003 in cooperation with the Kaštela Municipal Museum.

<sup>9</sup> In June 2009 the Lapidarium of the Archaeological Museum in Zagreb served as the open-air venue for the promotion and showing of the documentary about the Veternica cave. The event was organized in cooperation with a partner institution in the Neandertal Trail Project - the "Medvednica Nature Park" Public Institution. Similar events are planned for a number of other instances in relation with the project.

<sup>10</sup> The history of the development of cultural routes on the continental level started in the last decades of the 20<sup>th</sup> century, with the Pilgrim Routes of Santiago de Compostela as the first route that was awarded the status of a European Cultural Route in 1987. There are presently around thirty routes of such, pan-European character, including those of a predominantly archaeological nature, such as The Phoenicians' Route or The Viking Routes.

# LATE RED FIGURED POTTERY FROM EGNATIA (SOUTHERN ITALY): ATTIC TRADITION AND APULIAN TECHNOLOGICAL INNOVATION

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**Keywords:** Apulian red-figured pottery, scanning electron microscopy, atomic spectroscopy, black gloss and red decoration, production technology.

## 1. INTRODUCTION

This study has been carried out within a wider research project exploring technological aspects of Hellenistic ceramic production in Apulia, with particular reference to red figured and "Gnathia" pottery. The aim is to understand the shift in production dynamics from the Attic model to Apulian pottery that took place from the 4<sup>th</sup> century BC. This paper focuses on Apulian red figured pottery production coming from Egnatia[1], a site among the most relevant of ancient Messapia (corresponding to southern Apulia).

As emphasized in previous papers[2,3], archaeometric investigations on red figured pottery have so far mainly dealt with Attic production, mostly aimed at understanding the techniques utilized to produce the black gloss[4-12]. However, there is as yet a lack of data about Apulian red-figured pottery[2,3,13]. This production, at first a direct imitation of Attic vases, most probably began with the temporary transfer of expert craftsmen and artists from Taranto to the wealthiest Apulian villages, which later became the branch centres of production outside the main city. Apulian production can be differentiated from Attic production, especially in the Middle and Late period. This hypothesis originates from the discovery of a production technology of red figured vases in Peucetia (corresponding to central Apulia) during the late 4<sup>th</sup> century BC different from the "classic" Attic production[2,3]. The study, however, referred to a small number of objects, furthermore coming from a single site, cannot be considered representative of such complex, structured and assorted production. Thus, this study seeks, extending the investigation to another important archaeological site in southern Apulia, to address a number of objectives which are the correct classification of materials, the knowledge of technological features -allowing us to understand whether this pottery technology evolved during the 4th century BC, as for the findings of Peucetia, or if different technological procedures were used at different sites- and the identification of production locations.

The goal is to clarify, on the basis of unambiguous elements, the technological processes characterizing this particular kind of pottery and, most of all, to identify possible differences between objects that could help distinguish between the different production processes and workshops.

## 2. EXPERIMENTAL

A collection of 36 fragments, dating back from the late 4<sup>th</sup> centuries BC and coming from Occidental Necropolis and Penna grande (labelled with N and P respectively) were examined (Fig.1).

The fragments were examined with different complementary techniques, namely: polarized-light Optical Microscopy (OM); Scanning Electron Microscopy (SEM) with Energy Dispersive Spectrometry (EDS), X-ray Diffraction (XRD) and Inductively Coupled Plasma Emission Spectroscopy (ICP-MS). Multivariate statistical techniques were used for treating the compositional data.

Orthoscopic observations of the mineralogical textures were performed by means of an optical microscope (Carl Zeiss) on polished thin sections, which, after graphite sputter-coating, were investigated by SEM (EVO-50XVP (LEO)). Microanalyses were conducted using an Oxford-Link EDS instrument equipped with a PENTAFET Si(Li) detector and with a 0.4-mm-thick Super Atmosphere Thin Window (SATW).

The elemental chemical composition of the ceramic body of the samples was investigated; bulk ceramic matter was scraped off fractures already existing on the fragments, after removing the outermost external contaminated layer. Aliquots of about 30 mg of bulk ceramics, a good agreement between archaeological micro-destructivity and analytical data quality, were dissolved by acid attack in a Milestone Start D (FKV) with a solution of 37% HCl, 70% HNO<sub>3</sub> and 40% HF (Fluka trace selected for trace analysis reagents), in a 5:4:1 (v/v/v) ratio. Elements were quantified by ICP-MS (PERKIN ELMER Elan 9000 spectrometer); Indium (25 ppb) was used as internal standard.

External calibration with matrix matching standards was employed for quantification and five replicate readings were performed on both standards and samples.

X-ray diffraction analysis was performed by using a Philips X'Pert Pro X-Ray diffractometer, with the following working conditions: CuK $\alpha$  Ni-filtered radiation; 40 kV, 40 mA; divergence slit 1°, anti-scatter slit 0.5°, receiving slit 0.2 mm, speed 0.5° in 2 $\theta$  per minute.



**Figure 1.** Archaeological site of Egnatia, with indications of the main contexts-monuments: 2. 'Acropoli'; 5. 'Piazza lastricata e porticata'; 6. 'Anfiteatro'; 7. 'Sacello delle divinità orientali'; 8. 'Basilica civile'; 16. 'Via Traiana'; 9. 'Basilica episcopale'; 13. 'Porto'; 12. 'Terme'; 15. 'Necropoli occidentale'; 19. 'Penna Grande'.

### 3. RESULTS AND DISCUSSION

#### 3.1. CHEMICAL ANALYSIS OF CERAMIC BODY AND STATISTICAL TREATMENT OF DATA

Results of chemical elemental analysis of bulk material are reported in Table 1; major and minor elements are expressed in weight per cent of their conventional stoichiometric oxides and trace elements in parts per million (ppm). These compositional data were processed with Principal Components Analysis (PCA), using the SCAN software package (Minitab), with the main aim of identifying groups of objects distinguished on the basis of their compositional features.

The concentration of 16 elements of the ceramic body was determined, but statistical analysis was performed on a matrix of 10 chemical parameters, excluding from the statistical treatment the compositional data relative to a few



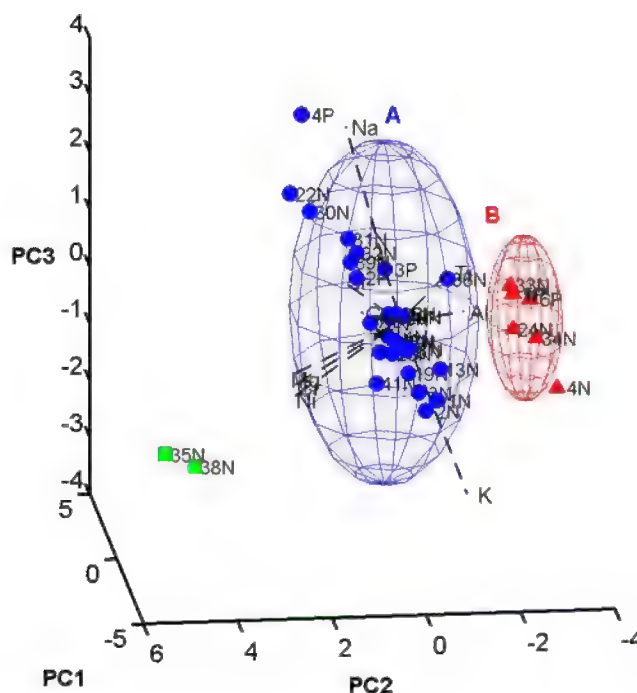
irrelevant parameters, which can only complicate a good classification. These parameters were identified by using statistic criterion of selecting features, for example comparing the means and the variances of the different variables before PCA was applied.

The results of the multivariate statistical treatment are shown in Fig.2, illustrating the scores plotted on to the first three principal components subspace, which accounts for 82% of the total variance, and the loading plot of the different parameters. Two distinct clusters – A and B - can be identified. The same figure shows 95% isoprobability ellipsoids, whose surfaces define the boundary of the identified clusters. Samples 35 and 38 are outliers of the individuated clusters.

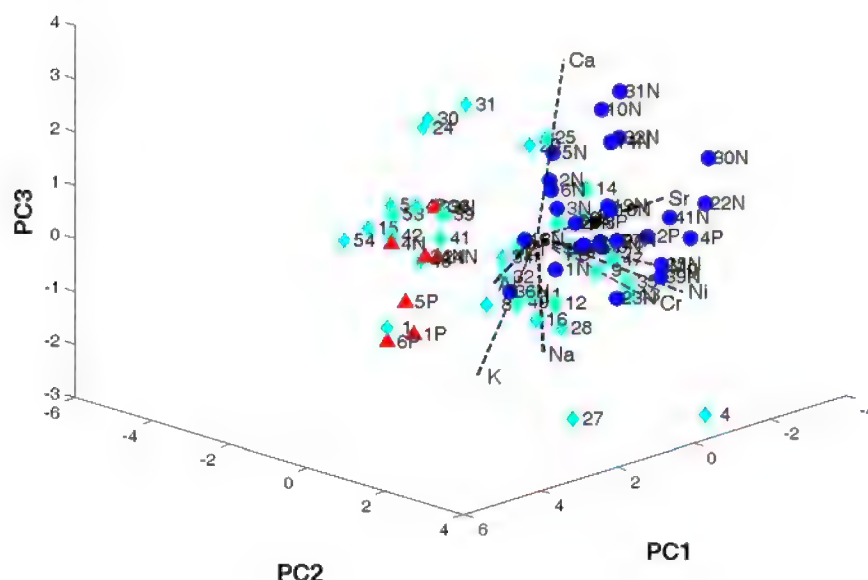
Cluster A differs from B along PC1 principally due to the loadings relative to Al, Fe and Ti parameters. In particular, the A scores are characterized by positive values of PC1 due to higher amounts of Fe and Ti. The widening of both clusters along the PC3 is mainly due to the loadings of Na, K and Sr.

To confirm both the local production of objects and the close relationship, from a technological and not only from a morphological and decorative point of view, between “*Gnathia*” and Apulian figured pottery [1,2,3], multivariate analysis was extended to the ceramic body compositional data of coeval “*Gnathia*” pottery from *Egnatia*. As shown in Fig.3, both pottery typology merge into the same macro-group of objects, giving value to their production in *Egnatia*. In particular some of “*Gnathia*” pottery finds group with finds of cluster A, other with that of cluster B. It is interesting to note the position of the score of fragment 8P, a “*Gnathia*” pottery find coming from the same tomb of some red figured pottery coming from Penna Grande.

To identify the reasons that split the scores of fragments into the different clusters and to check if their marked compositional diversity is accompanied by differences in production technology the fragments were examined from the minero-petrographical point of view.



**Figure 2.** Scores and loadings diagram for the first three principal components related to the objects examined. The accounted variance is 82% of the total variance. 95% isoprobability ellipsoids, whose surfaces define the boundary of two clusters: A and B, are also reported.



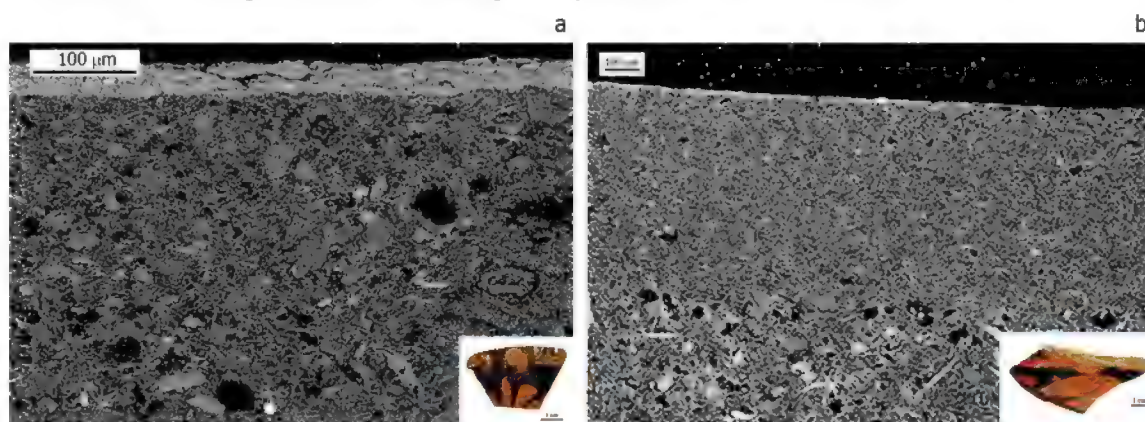
**Figure 3.** Scores and loadings diagram for the first three principal components related to Apulian red figured pottery and “Gnathia” pottery from Egnatia. Markers: red triangle for Apulian red figured pottery belonging to cluster B, blue circle for Apulian red figured pottery belonging to cluster A, turquoise diamond for “Gnathia” pottery and black triangle for 8P sample .

### 3.2. MORPHO-MINERALOGICAL CHARACTERIZATION BY OM AND SEM-EDS ANALYSIS

#### 3.2.1. CERAMIC BODY

The splitting of the scores of fragments into two different clusters agree with their different minero-petrographic characteristics. In fact, even if fragments of all clusters are characterized by silty-clay texture with flakes mainly of quartz, mica, Fe oxides and hydroxides and, to a lesser extent, feldspar and plagioclase, they differ for the coating structure. In particular, for fragments of cluster A an evident morphological and compositional continuity between the red-coloured surface and the bulk can be observed and black gloss is layered directly on the ceramic body, on the contrary, for fragments of cluster B a red engobe layer with transitional characteristic between black gloss and ceramic body (texture, sintering degree and chemistry), is present on the clay paste, before the black gloss painting (Fig.4).

Even though, for objects of both clusters, crystals containing calcium are not visible, by OM images, the composition of ceramic bodies highlighted high quantities of Ca, unevenly distributed -more and less luminous zones in the SEM image, which, identified as calcite by XRD analysis, suggest the presence of microcrystalline calcite. Raw materials coming from alluvium or eluvial deposits, characterized by the presence of “terra rossa”, quartz and calcite due to superficial erosion, were probably used.



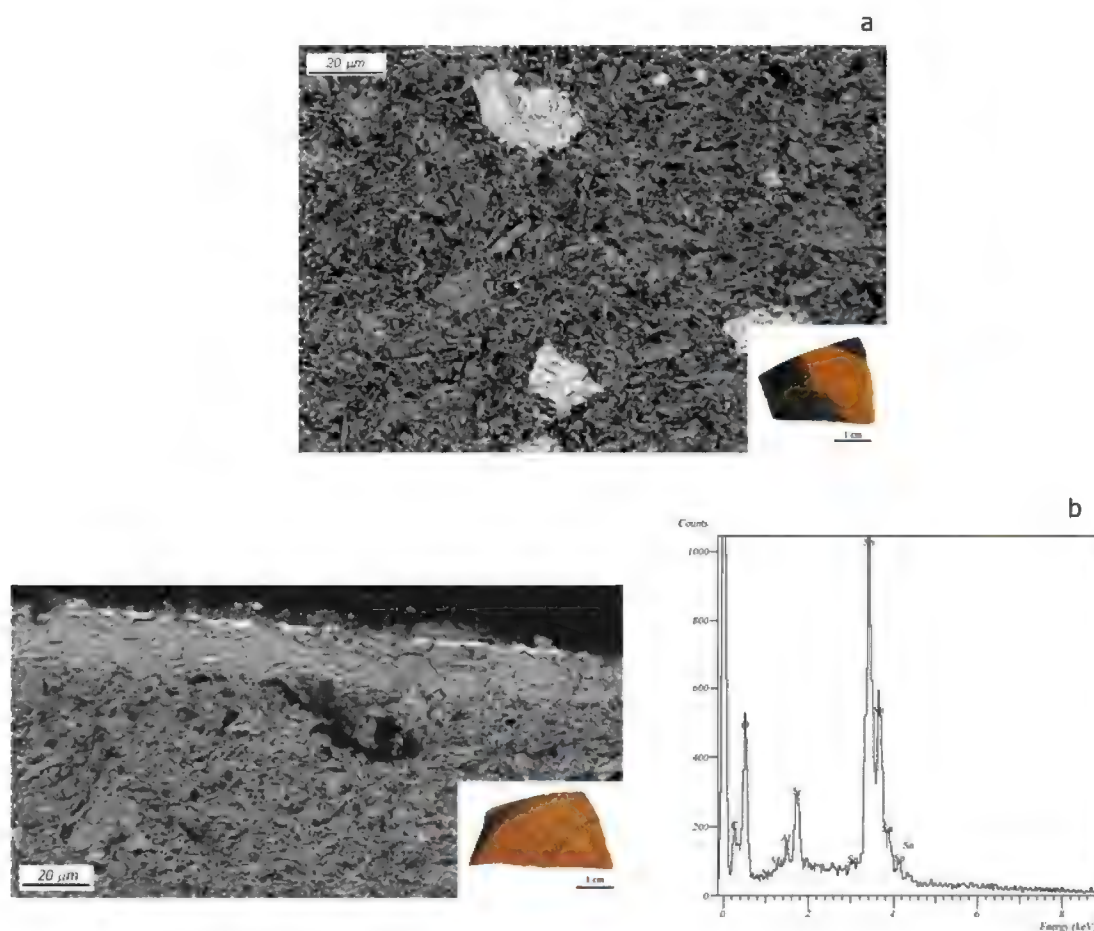
**Figure 4:** Scanning Electron Microscopy-Back Scattered Electron (SEM-BSE) photomicrographs of thin sections of shards: a) 28N showing black gloss (upper) and ceramic body, b) 5N showing, from upper to lower: black gloss (brighter), ingobbio rosso (light grey) and ceramic body (dark grey) and ED spectra of ingobbio rosso (b) and ceramic body (c).

### 3.2.2. BLACK GLOSS

The “black gloss” on all samples revealed an average thickness of about 20  $\mu\text{m}$ ; a very compact structure -no voids, large degree of sintering, no clay structure evident- indicating that a finer clay in comparison with the ceramic body, probably with a granulometry lower than 2  $\mu\text{m}$ , was used in its production. An homogeneous chemical composition through all samples, with larger quantities of Al, Fe, K and lower quantities of Ca, with respect to the ceramic body was revealed. The use of the so called “*terre rosse*” is compatible with our data. “*Terre rosse*”, very common all over Apulia, are continental sedimentary layers characterized by a silty-clay granulometry. Their mineralogical composition includes mainly partially crystalline Fe and Al oxides and hydroxides, clay minerals (illite and kaolinite) and traces of quartz, feldspars, micas, pyroxenes and other minerals. The thinnest fraction of such “*terre rosse*”, easily separated by decantation, could have been used to realize these black glosses. In fact, this fraction, richer in kaolinite and illite as well as in Fe and Al oxides, could give the gloss investigated its technological and chemical properties.

The outlying position of samples 35 and 38, highlighted by statistical analysis, is confirmed by the minero-petrographic characteristics of these objects, which are different from the others.

In fact, chromites and rare earth phosphates (Fig. 5) are present in the ceramic body and a very thin Sn based layer is present on the black gloss. The presence of Sn could explain the matt aspect of these glosses, just evidenced for these samples by autoptical analyses



**Figure 5:** Scanning Electron Microscopy-Back Scattered Electron (SEM-BSE) photomicrographs showing: a) ceramic body of the sample 35N, b) Sn layer on the black gloss of the sample 38N.

### 3. CONCLUSIONS

These results confirm that there were two different production technologies of red figured vases in Apulia during the 4<sup>th</sup> century BC. Certain vases were produced with the “classic” Attic technology, other vases with a different technology which used the application of the engobe layer. The discovery of fragments with these peculiar technological features not only in Peucetia, but also in Egnatia proves that the use of this technological expedient was not an isolated device, but it was quite common in the production of late red figured in Apulia.

This production evolution was very probably started by the need for better material, from the mechanical and structural point of view, to make larger vases typical of the Apulian production of the late 4<sup>th</sup> century BC. It is not possible to exclude, however, that the production could be diversified depending on the final use of the item (*e.g.*, for daily use, for a burial, etc.) and on the customer target especially in the Late period when the production increase and the separation between low-quality mass production and the excellent artistic items by the most famous artists became sharper. At the same time, it is not possible to exclude that, also in the Late period, importation from Greek colonies or directly from Greece have been taking place, how it would look the diversity of some objects, found together with typical Late Apulian red figured ones in same tombs.

Only the extension of this investigation to other important archaeological sites in central and northern Apulia will allow us finally to clarify the questions.

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## PALAEOENVIRONMENTAL RECONSTRUCTION OF THE ARCHAEOLOGICAL SITE OF ARSLANTEPE (EASTERN ANATOLIA)

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The site of Arslantepe (Arslan = Lion; Tepe = mound), in the Malatya plain (Turkey), is a hill, 30 m high, formed by an artificial accumulation of anthropogenic sediments, made of collapsed buildings and a series of superimposed villages. The life of the site started much earlier though, at least in the VI millennium BC and continued uninterruptedly until the Late Roman and Byzantine times.

Its history fully exemplifies the transformations of society in the region since prehistoric times and the site is an inextinguishable source of precious information of all kinds, due to the strongly interdisciplinary character of the performed research. Excavations of the "La Sapienza" University of Rome at the site of Arslantepe have been carried out uninterruptedly since 1961, bringing to a lot of archaeobotanical material source by the entire sequence of occupation of the site.

The archaeobotanical studies highlighted the presence of various botanical taxa preserved by charring, belonging to arboreal and crop species. Great variety was found, the diversity in taxa and the selective use of wood can be either due to a choice or even to an environmental availability.

Most recent studies on the stable carbon isotope of carbon show that  $\delta^{13}\text{C}$  values of both fresh and charred wood contain proxy environmental features. The  $^{13}\text{C}/^{12}\text{C}$  ratio in plants depends mainly on the photosynthetic pathway and stomatal conductance, affected by several environmental factors, such as concentration and isotopic ratio of atmospheric  $\text{CO}_2$ , water use efficiency and environmental condition (i.e. temperature and rainfall). So the comparison of  $\delta^{13}\text{C}$  values in different periods can be related to drought stress (Farquhar et al. 1989; Hall et al. 2008, Riehl et al. 2008).

A lot of studies correlated cultural changes with environmental factors. At Arslantepe a number of important changes are found. It is not clear, however, if the important variations found in plants use by the successive settlers are due to cultural choices or to environmental changes. Independent information on environmental variation obtained using Carbon stable isotope, will help classical archaeobotanical studies to discriminate cultural and environmental change and reciprocal influences. A comparison between wood and seeds trends of  $^{13}\text{C}/^{12}\text{C}$  ratio could give information on irrigation of crop.

A preliminary analysis of selected fossil woods of *Quercus* and *Juniperus* from the archaeological site (mainly branches) were carried out at IGG-CNR of Pisa. The samples, cleaned and grounded into a homogeneous powder, were analysed using an Elemental Analyzer coupling with isotope ratio mass spectrometer (Delta plus XP Finnigan). The results are expressed as per mill deviations relative to the conventional standards, PDB, that is

$\delta^{13}\text{C} = \left[ \left( \frac{^{13}\text{C}/^{12}\text{C}_{\text{sample}}}{^{13}\text{C}/^{12}\text{C}_{\text{standard}}} - 1 \right) \right] \times 1000 \text{ (‰)}$

Fresh reference plant specimens (leaf and branches) of the same taxa have been sampled in the area of Arslantepe, dried at 45 °C and processed with the same method used for fossils.

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## **THE BELL TOWERS OF S.GIOVANNI IN LATERANO (ROMA): THE ARCHAEOBOTANICAL SUPPORT TO ARCHITECTURE**

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In the frame of a strict collaboration between architects and archaeobotanists of University of Rome "La Sapienza", aimed to integrate architectonical research with analyses on plant material related to structural elements of historical buildings of medieval and renaissance age, the study of the bell towers of Basilica di S.Giovanni in Laterano in Rome has been undertaken.

According to the historical sources the northern façade had two stair defence towers since the X cent., only after evolved in bell towers under the rule of Pope Innocenzo III (1196-1216). This pope in fact reinforced the belfries and supplied them with four bells.

The construction of the bell towers dates back to the XI and XII century.

The two binate belfries show a square map structure, more or less regular, with a central pilaster around which a stair, composed by four by four flights, round. The walls are formed both by bricks and small block of tuff. The towers have an height exceeding 25 m. Today the two bell towers are hidden by the Loggia delle Benedizioni, built by Domenico Fontana in 1586.

The vaults have been built using a base of interlaced mats laying on the centering realized with mortar and lapideous elements. The mats, once removed, left a singular imprint formed by little squares. This particular manufacture attracted our interest and is the subject of an archaeobotanical analysis.

The kind of technique used to build the vault shows intriguing aspects. It appeared in Rome during the XII-XIII centuries to disappear abruptly. Only few other examples can be found, namely in the monasteries of Ss. Quattro Coronati, S. Lorenzo fuori le mura and S. Clemente.

The S. Giovanni bell towers show an almost undisturbed example, not only for the scarce renewal interventions but above all because its inner parts were not refined, so that consistent remains of the mats and woods used by the workers are in situ.

Preliminary sampling of the mats indicates that they were made with reeds. Further sampling turns out necessary because in the analyzed reed matting, due to the poor state of preservation of organic matter, no diagnostic anatomical structures were found. The wood of the cases in which the bell ropes were housed is in study. First results show that the timber was also in this case badly preserved, being almost completely destroyed by termites.

Archaeobotanical analyses could be of great help, together with historical and architectural studies, to define the dating and to clarify the construction techniques.

## INDEX OF LICHEN POTENTIAL BIODETERIOGENIC ACTIVITY: CALL FOR VALIDATION

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### Abstract

Lichens growing on rocks cause physico-chemical deterioration processes, being particularly harmful when they colonize stonework. Considering the different aims and experimental approaches, the countless researches about lichen deterioration are not so adequate to assess the lichen biodeteriogenic activity on stonework and thus to plan proportionate conservation programs. Recently, an Index of Lichen Potential Biodeteriogenic Activity (LPBA) has been tentatively proposed to organize information, available from both previous literature and new researches for the evaluation of the potential risk associated to lichen colonization, since different species on different lithotypes may cause different effects, ranging from biodeterioration to bioprotection.

The application of the LPBA index to more and more case studies in Italy but also in the whole Mediterranean basin is wished for, in order to validate the index parameters and to create an interpretation scale.

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**Keywords:** lichens, biodeterioration, LPBA index, stonework

### 1. INTRODUCTION

The Mediterranean Basin is undoubtedly an area with an extremely rich tangible cultural heritage, with a considerable quantity of stonework exposed to the action of abiotic and biotic agents. However, only recently people that work in the field of conservation for the safeguard of Cultural Heritage have started to tackle the question of biodeterioration of worked stone in an interdisciplinary way [1].

Lichen-forming fungi play an important role as biogeophysical and biogeochemical agents in the degradation of stonework surfaces, creating particular problems for their conservation [2], [3]. Many researches have been performed on the deterioration activity of lichens [4], but their different aims and experimental approaches make the actual knowledge rarely helpful to quantify the biodeteriogenic activity on stonework and to plan management programs considering both of the conservation of Cultural Heritage, and of the safeguard of lichen biodiversity as an additional cultural value [5].

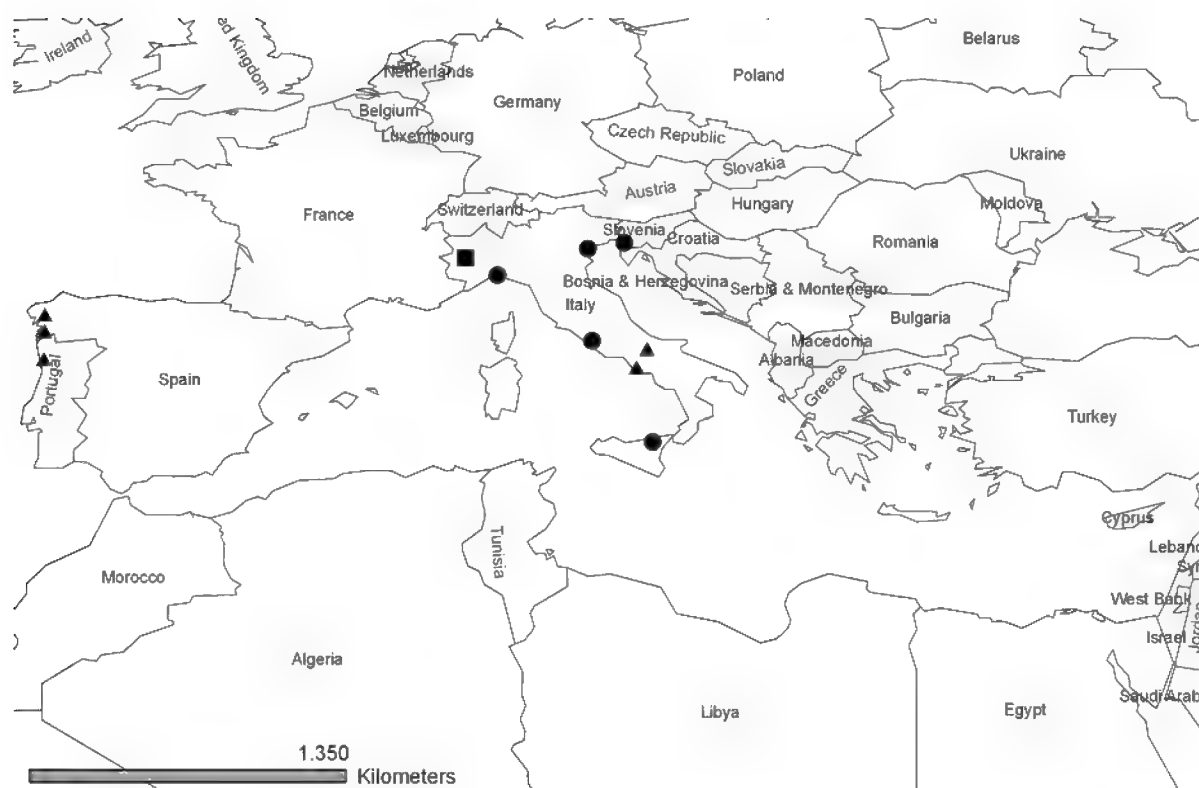
A new practical tool may organize information available from both previous literature and new researches for the evaluation of the biodeteriogenic activity of lichens. For this purpose, an index of Lichen Potential Biodeteriogenic Activity (LPBA) has been recently proposed. The LPBA index measures the impact of lichens on stonework on the basis of the volume of influence of each species, quantified both on the surface of and within the substratum, and of other parameters related to reproduction, physico-chemical action, and bioprotection [6].

A statistical validation of the index has now to be carried out by extending its application to case studies on different lithotypes and in different climatic regions, thus allowing the calibration of the parameter scales and the elaboration of an interpretative index scale. Such a calibration appears to be very demanding and consequently difficult to carry out by isolated research groups while a validation based on a stratified case-study definition would be successfully carried out by a research network developed in the Mediterranean basin. A typification of case studies which may be particularly suitable for validation is proposed, looking for the collaboration of colleagues towards the use of the LPBA index in the context of the EACH Project.

### 2. VALIDATION PROGRAM OF THE LPBA INDEX

#### 2.1. Elaboration of the index interpretative scale

The index has been preliminary applied to six case studies in Northern Italy [6], but the application to a wide set of case studies, covering different (i) stonework types, (ii) lithotypes, (iii) climates, is necessary to define and validate an interpretative scale for the calculated index values, supporting a reasonable management of the stone cultural heritage colonized by lichens. In order to achieve this goal, a network of collaboration (named “partners” in Fig. 1) covering the Mediterranean Basin is currently under formation.



**Fig. 1.** Map showing the research groups which already join the network for the LPBA index calibration:

- square: project coordination (University of Torino);
- circles: co-proposers (Univ. Roma Tre, Catania, Genova, Trieste; ISCR Roma; Soprint. Venezia);
- triangles: partners since the Cairo Congress 2009: G. Aprile - Univ. of Napoli; S. Ravera - Univ. of Molise; J. Marques - Univ. of Porto; B. Prieto Lamas - Univ. of Santiago; G. Paz-Bermudez - Univ. de Vigo.

A form comprising guidelines for compilation has been prepared: it allows to collect data about each case study (Fig. 2). Contributors can fill the form with the information available. Small sets of data are also useful. If data on parameters “c-d-e-f” are not available, contributors are invited to send to the coordinator of the project samples suitable to prepare and analyze cross-sections to fill the gap. If authorised by the contributors, representative cross-sections will be added to the Lichen-Petrographic collection of the University of Torino ([http://web086.unito.it/cgi-bin/bioveg/documenti.pl/Show?\\_id=e4f3](http://web086.unito.it/cgi-bin/bioveg/documenti.pl/Show?_id=e4f3)); other sections will be sent back to the contributors.

The guidelines included in the schedule are reported below:

- 1) *stonework* - if the requested information are not available or not pertinent to the examined stonework, they have to be marked with “f”;
- 2) *climate* - possibly reporting instrumental data on temperature, humidity, wind, precipitation, number of freeze-thaw events for year, etc...;
- 3) *category* - categories could be: archaeological area, building, statue, tombstone, fountain, pot, etc...; possibly including information on size for small stonework;
- 4) *lithotype(s)* - possibly including information on the main rock-forming minerals to avoid misunderstanding due to commercial or local names;
- 5) *conservation* - possibly including information on current management approach, public enjoyment (in terms of aesthetic disturbance), past restorations, abiological damages, etc...;
- 6) *cover* - all approaches yielding a quantification of total and specific cover (%) are accepted (e.g. complete surveys of “small” surfaces; expert visual estimation of total cover and dominant species on buildings; phytosociological



relevés in preferentially or randomly selected plots on “small” surfaces, buildings, archaeological and monumental areas, following as much as possible the Braun-Blanquet’s rules depending on the possibility to select homogeneous surfaces; etc), but not frequency data;

7) *reproductive potency* - contributors should distinguish (a) species displaying asexual reproduction; (b) species displaying sexual reproduction and having many fertile ascocarps; (c) species displaying sexual reproduction but ascocarps without spores or no ascocarps. The evaluation has to be generically based on the reproductive strategy of each species or rather on the current state of development of reproductive structures of individuals in the examined site. Microscopic observation of cross sectioned fruiting bodies gives information on the occurrence of fertile asci in the individuals;

8) *depth of hyphal penetration* - it can be evaluated on polished cross sections stained with Periodic Acid Schiff observed under light microscopy or on fracture samples observed under electronic microscopy, etc .... Values representative of the average penetration depth and values obtained with a random sampling of penetration data are equally accepted. It is worth noting that conservative policies often limit or avoid sampling operations, preventing the preparation of thin or polished cross-sections. In these cases, however, sampling in natural outcrops of the same lithotype, where the same species or systematically related species may develop, can offer useful material for cross section preparation;

9) *physical action* - contributors should distinguish: (a) disaggregation of rock below thalli appreciable at a macroscopic scale (visual observation); (b) occurrence of lithic fragments deriving from the disaggregation of the substratum and included in the medulla observable through light microscopy (observation of cross sections); (c) no disaggregation at both the macroscopic and microscopic scale (visual observation and observation of cross sections);

10) *chemical action* - contributors should distinguish: (a) species secreting oxalic acid; (b) species secreting secondary metabolites having mineral-leaching effect; (c) species having pitting effect caused by unknown chemical processes; (d) species secreting secondary metabolites not having mineral-leaching effects; (e) species not secreting any secondary metabolite. The secretion of oxalic acid can be easily recognized by recovering oxalates as neogenesis minerals at the lichen-rock interface. A culture of mycobionts in the aposymbiotic state is also informative on the secretion of oxalic acid by a species because of the formation of oxalates in/on the culture medium. Information on the production of secondary metabolites, a taxonomically-significant specific feature, can be obtained from literature, but the action of each metabolite in terms of mineral leaching should be, at the end, evaluated through ad hoc incubation experiments (some data are available in literature). Pitting is appreciable at naked eye or by observing thin-cross sections under light microscopy;

11) *hyphal spread* - this parameter has been recently introduced in the analysis of lichen deterioration by Gazzano and colleagues (Lichenologist 41: 299-313). Hyphal spread can be best quantified applying image analysis to PAS-stained polished cross sections;

12) *bioprotection* - when areas covered by lichens are less eroded and/or disaggregated than uncolonized adjacent areas, bioprotection processes should be supposed. Information from literature on the biocovering effect of the species on the examined lithotype has also to be considered.

[illegible]

**Fig. 2.** Form for the acquisition of data for the LPBA index calibration: A, general information; B, parameter values collected for the species colonizing the substratum in the case study.

## 2.2. Calibration of the parameter scales

The ordinal scales preliminary proposed to quantify five out of the seven parameters adopted in the index still need to be adjusted and validated by examining suitable case studies in the field and/or through laboratory experiments (Tab. I). In particular, the reproductive potency may be better estimated considering (i) field case studies supported by a long-term documentation (*e.g.* photographic) showing an increase of lichen colonization by asexual/sexual species and (ii) laboratory experiments in controlled conditions.

Case studies (based on the observation of cross-sections) showing the occurrence or absence of relationship between the depth of hyphal penetration and the extension of physical fragmentation and chemical deterioration (e.g. iron-rich patinas) beneath the thalli may allow a better definition of the scale related to the depth of hyphal penetration.

Case studies of artworks as statues or high-bas-reliefs which allow to quantify the effects of macro- and microfragment detachment on the surface readability could highlight the physical actions driven by lichens. Tests on mineral dissolution by incubating rock slabs with pure lichen metabolites or isolated lichen mycobionts could highlight the chemical actions driven by lichens.

Finally, any contribution about bioprotection may improve its quantification because of the general lack of data about this phenomenon.

**Tab. I.** Parameter ordinal scales proposed for the calculation of the LPBA index [6].

Parameter	Ordinal scales	
Reproductive potency	10	species displaying asexual reproduction
	5	species displaying sexual reproduction and having fertile ascocarps
	1	species displaying sexual reproduction but young ascocarps without spores or no ascocarps
Depth of hyphal penetration	10	> 2000 $\mu\text{m}$ , i.e. measures comparable with gravel diameter
	5	between 2000 and 500 $\mu\text{m}$ , i.e. measures comparable with coarse-
	2	between 500 and 50 $\mu\text{m}$ , i.e. measures comparable with fine-sand diameter
	1	< 50 $\mu\text{m}$ , measures comparable with silt and clay diameter
Physical action	5	thallus detachment of rock fragments is appreciable at the macroscopic scale
	3	medullar or hyphal inclusion of lithic fragments deriving from the disaggregation of the substratum is observed by light microscopy
	1	no disaggregation is appreciable at both the macroscopic and microscopic scale
Chemical action	5	species secreting oxalic acid
	3	species secreting secondary metabolites having mineral leaching effect and species having pitting effect caused by unknown chemical processes
	0	species secreting secondary metabolites not having mineral-leaching effects or species not secreting any secondary metabolite
Hyphal spread	1	volume of rock occupied by hyphae > 50%
	0.7	50-20%
	0.3	20-5%
	0.1	< 5%

### 3. CONCLUSIONS

The calculation of the LPBA index was the first step towards the definition of a practical tool useful for the management of lichen colonization on stonework, finally allowing the conservation of cultural heritage and the preservation of lichen biodiversity.

The formation of an international research network appears the unique and fundamental way to validate this index. The goal is the achievement of a large adhesion which could cover all the areas of the Mediterranean basin. The proposed form will facilitate the acquisition and the management of data from all the involved research groups.

The validation of the index for lichens could be a model for the calculation of similar indices for other taxonomic groups colonizing Cultural Heritage.

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## USE OF BIOCIDES WITH DITERPENOID NATURAL VARNISHES (COLOPHONY) AGAINST MICROBIOLOGICAL BIODETERIORATION OF WORKS OF ART

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### Abstract

The biocides benzalkonium chloride, orthophenyl phenol, and tributyltin naphthenate, all of them widely used in restoration, were applied in test specimens prepared with colophony and inoculated with fungi and bacteria. Samples were analyzed by optical microscopy and gas chromatography–mass spectrometry (GC–MS) to determine the effectiveness of the studied biocides against these microorganisms and their possible adverse effects on the varnish. Obtained results point out that using biocides associated to protective varnishes can be an efficient procedure to protect works of art with scant adverse effects for their aspect and conservation.

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**Keywords:** colophony, biodeterioration, biocides, fungi, bacteria

### 1. INTRODUCTION

The use of biocides to control the development of biological agents responsible for biodeterioration process is a frequent task in restoration and conservation of works of art. This study deals with the possibility of employing these substances associated to final protection layer (varnishes) in pictorial works of art and polychromed sculpture.

### 2. MATERIAL AND METHODS

#### 2.1 Microorganisms

Microorganisms were selected on the basis of their capacity to grow and to produce chemical changes in resins, as was reported in earlier works of our research group [1-3]. The fungi *Chrysomya sitophila* was isolated from surface of oil on canvas paintings of the Fine Arts Museum of Granada (Spain) severely affected by biodeterioration processes (Figure 1). *Bacillus amyloliquefaciens* (Ba) (CECT-493) came from stock collections belonging to the Spanish Collection of Type Cultures (CECT, Universidad de Valencia, Valencia, Spain)



**Figure 1** *C. sitophila* was isolated from St. Francis of Assisi (anonymous, 17th century), Fine Arts Museum of Granada (Spain).



## 2.2 Test specimens preparation

The biocides Tributyltin naphthenate (Metatín N 5810/101, Ácima Chemical Industries), Orthophenyl phenol (Preventol ON, Bayer), and Benzalkonium chloride (Caremi Pigmentos) were used to prepare colophony varnish with biocide incorporated (3% v/v). The varnish was applied by brush in three successive layers (0.5 mm thickness) in glass slides of standard size (24x80 mm).

Bacterial ( $10^7$ - $10^8$  cells  $\text{ml}^{-1}$ ) and spore suspensions ( $10^6$  spore  $\text{ml}^{-1}$ ) of, respectively, *Bacillus amyloliquefaciens* (Ba) and *Chrysonilia sitophila* (Cs) were prepared. Any possible remain of culture media was eliminated.

Three groups of test specimens were prepared, in order to compare the chemical changes produced in colophony in samples treated and not treated with biocides: colophony varnish, colophony varnish inoculated with microorganism, and colophony varnish treated with biocides and inoculated with microorganism.

The studied microorganisms were inoculated on test specimens with drops (75  $\mu\text{l}$ ) of suspensions described above. Test specimens were incubated for 15 days in darkness at 28 °C and 85-90% RH, water activity ( $a_w$ )=0.85.

## 2.3 Analytical techniques

A sterile scalpel was used to scrape the samples from the test specimens, providing about 0.5 mg. per sample. These were dissolved in 25  $\mu\text{l}$ . of benzene. Then, 25  $\mu\text{l}$ . of (m-trifluoro-methylphenyl) trimethylammonium hydroxide (Meth Prep II, Alltech) were added. The reaction mixture was shaken for about 40 min. at room temperature. 1  $\mu\text{l}$ . of the sample solution was injected into the GC. Analyses were carried out using a Platform II mass spectrometer (Micromass Instruments, UK) coupled to a Carlo Erba 8060 gas chromatograph (Thermo Instruments, USA). Chromatographic separations were achieved on a fused-silica capillary column (HP-1MS), (100% dimethylpolysiloxane), 30m. x 0.25 mm. I.D. and 0.25  $\mu\text{m}$ . film thickness. The chromatographic conditions for the GC-MS analysis were: injector temperature = 250°C, transfer line temperature = 300 °C, oven temperature = 120 °C (2 min.), 10 °C/min. to 300 °C then isothermal for 20 min. The carrier gas was helium at a flow-rate of 1.2 mL/min. Samples were injected in splitless mode. Mass spectra were performed in total ion monitoring mode (mass range 50-550  $m/z$ ) and ions were generated by electron impact ionisation (70 eV). The source temperature was 210 °C. A MassLynx v.4.0 data system was used for data acquisition and processing and the peak area (TIC) data were used to obtain peak area percentage value.

Calculations were based on values of the normalized peak area  $N_i$ , defined as the percentage of peak area of each individual compound relative to the set of peak areas of the  $n$  components found in the sample:

$$N_i = \frac{A_i}{\sum_{i=1}^n A_i} \times 100$$

where  $A_i$  is the peak area of each of the  $n$  compounds found in the chromatogram.

Blank samples, inoculated with distilled water and incubated under the same conditions as those of the samples inoculated with microorganisms, were also analysed to evaluate the composition of studied varnishes in the absence of microorganisms. The changes in the composition were determined by establishing a  $\Delta N_i$  parameter, defined as the increase or decrease in  $N_i$  for each analyte in relation to the values corresponding to the blank sample  $N_{io}$ .

$$\Delta N_i = N_i - N_{io}$$

A total of three replicates for each sample were used. The values considered for results were the average of the triplicate groups. The repeatability found under the experimental conditions and the relative standard deviations—calculated using the formula  $\text{RSD} = (\text{standard deviation}/\text{mean of the normalized peak area}) \times 100\%$ —fell within the range 1-5% for all the compounds analysed. The Student's t-test was used for comparison of the differences between means values of inoculated and non inoculated (blank) samples. Only the values with a  $P < 0.05$  were considered statistically significant.

### 3. RESULTS AND DISCUSSION

Results are shown in Table 1. In test specimens inoculated with microorganisms and not treated with biocides, the main trend observed respect to the blank sample (colophony non inoculated-non treated with biocides) was a strong increase of oxidized diterpenoids, especially of 7-oxo-DHA and 7-oxo-15-OH-DHA ( $P < 0.05$  in all cases).

**Table 1.** GC-MS analysis ( $P < 0.05$  in all cases) of colophony varnish samples (in bolds), colophony inoculated with microorganism (in italics), and colophony treated with biocides mixed with the varnish and inoculated with microorganism. Values corresponding to colophony control samples are expressed in Ni (in bolds), and the rest of values are expressed in  $\Delta Ni$ . DHA=dehydroabietic acid; AA=abietic acid; 7-oxo-DHA=7-oxo-dehydroabietic acid; 15-OH-7-oxo-DHA=15 hydroxy-7-oxo-dehydroabietic acid).

	<b>DHA</b>	<b>AA</b>	<b>7-OH-DHA</b>	<b>15-OH-DHA</b>	<b>7-oxo-DHA</b>	<b>15-OH-7-oxo-DHA</b>
<b>Colophony</b>	<b>58.00</b>	<b>9.76</b>	<b>2.94</b>	<b>9.46</b>	<b>6.07</b>	<b>0.95</b>
<i>Colophony-Cs</i>	49.79 (-8.21)	0 (-9.76)	3.00 (-0.06)	7.30 (-2.16)	17.87 (+11.80)	2.57 (+1.62)
<i>Colophony-Ba</i>	22.16 (-35.84)	0 (-9.76)	5.58 (-2.64)	13.27 (+3.81)	38.71 (+32.64)	15.45 (+14.50)
Colophony- Benzalkonium chloride-Ba	57.13 (-0.87*)	2.44 (-7.32)	1.59 (-1.35)	6.77 (-2.69)	6.08 (+0.01)	Tr
Colophony- Tributyltin naphthenate-Ba	43.66 (-14.34)	36.77 (+27.01)	0.97 (-1.97)	4.50 (-4.96)	0.62 (-5.38)	Tr
<i>Colophony</i> Orthophenyl phenol- Ba	53.20 (-4.80)	11.52 (+1.76)	1.11 (-1.83)	3.25 (-6.21)	0.57 (-5.50)	Tr

These results differ significantly with those obtained in samples treated with biocides. The growth of the fungus *C.sitophila* (Figure 2) was completely inhibited in these test specimens (analytical data not included in the table 1, for being very similar to those of not inoculated samples). Likewise, the chemical changes found in samples with biocide and inoculated with *B. amyloliquefaciens* were not very significant. In no case a rise of oxidized derivatives was reported, which point out the effectiveness of the proposed treatments. In test samples added with tributyltin naphthenate, a reducer effect was observed (increase of AA and decrease of DHA and oxidized derivatives), presumably caused by the presence of Sn.



**Figure 2.** Microphotograph (400x) showing the development of *C. sitophila* in colophony (without biocides) test specimens after 15 days of incubation.

#### 4. CONCLUSIONS

The use of biocides mixed with colophony varnish inhibited the development of *C. sitophila*.

The analytical results have not shown significant changes in the resins inoculated with *C. sitophila* and *B. amyloliquefaciens* with respect to blank samples. The augment in the oxidized forms of abietanic diterpenoids observed in samples inoculated with microorganisms and not treated with biocides was not reported.

Obtained results point out that using biocides associated to abietanic protective varnishes can be an efficient procedure to protect works of art with scant adverse effects for their aspect and conservation.

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## FUENTE DE LOS LEONES (LION FOUNTAIN) OF THE ALHAMBRA: DETERIORATION MACROSCOPIC FORMS

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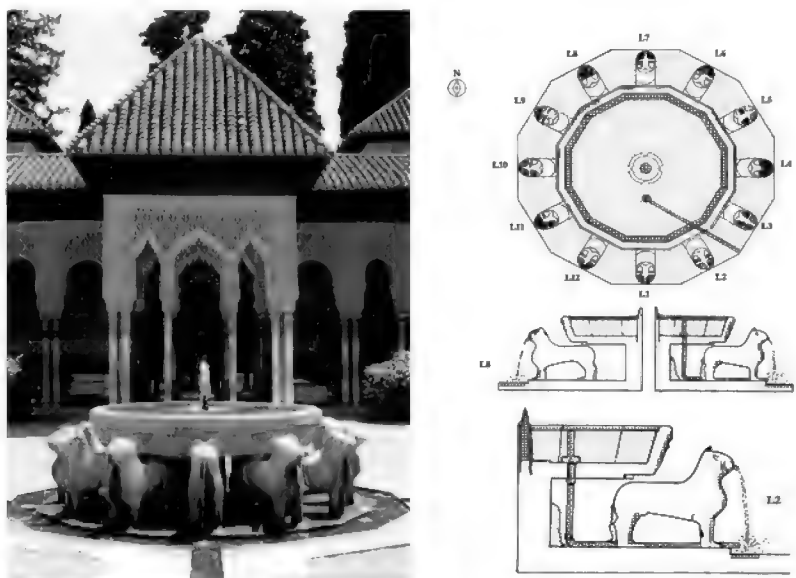
### Abstract

The Fuente de los Leones (Fountain of the Lions) from the famous Patio de los Leones (Court of the Lions) in the Alhambra of Granada (Spain), has been subjected, over its long history, to changes and modifications. It has also suffered the intense deterioration caused by natural agents, which have produced physical, chemical and biological alterations. In this work, the possible factors affecting the fountain, leading it to its present state, are studied. Special attention is given to biological factors that have not previously been considered. The terminology referring to the alterations is discussed and compared with that used by other authors, to provide precise definition of meanings. The study examines the main problems in preservation, related to the activity of the biological organisms detected. The importance of these problems is emphasised to avoid their omission in later maintenance and conservation.

**Keywords:** Lion fountain, Alhambra, biodeterioration, Macael marble, SEM-EDX.

### 1. INTRODUCTION

The Fuente de los Leones has a central position in the Patio of the Lions, and consists of a twelve-sided sculpted and inscribed basin of 2.52 m in diameter. It appears to be supported by 12 hieratic lions which spurt water from their mouths but in fact it is supported by a simple central cylinder. Contrary to appearance, all the lions are quite distinct, not only for their degree of alteration, but also for the different styles of the different sculptors. The lions, each one with an independent pipe, spill their water from their mouths, into a shallow channel which encircles the fountain and connects with four channels from the surrounding rooms and galleries (Fig. 1). The original basin was apparently replaced by another of similar dimensions, with the sides somewhat more inclined, to be used as an ablution fountain and to harmonise with the general style and decoration of the patio, according to Cabanelas-Rodríguez [1]



**Figure 1:** The Fuente de los Leones, as it stands today, consists of a twelve-sided sculpted and inscribed basin of 2.52 m in diameter. It appears to be supported by 12 lions which spurt water from their mouths, but in fact it is supported by a simple central cylinder.

Few technical studies examine the deterioration of fountains and marble in the Alhambra (Granada, Spain). Bello et al. [2] examined the marble columns of the various palaces of the Alhambra as well as the main fountain, called Fuente de los Leones (Lion Fountain). Some additional works [3,4] only partially published, concerning these monuments, but these studies, technical in nature, treated only the marble lions while excluding the basin of the fountain, the central support, the drainage channels and the pavement. The forms of deterioration existing in the



fountain must be established in order to specify the treatment phases with assurance and thus formulate the correct conservation programme

## 2. METHODOLOGY

To define the deterioration observed in the fountains, we partly followed the terminology proposed in the different works [5-10]. For the graphic representation, we used Letraset, as recommended by the Consiglio Nazionale di Ricerca (CNR) and the Instituto Centrale per il Restauro" (ICR).

Given the nature and situation of the materials studied, we had to introduce and define new terms specific to ornamental fountains: accretion, undulations, groove, nodules, delamination, disfigurement, encrustation, malfunction, plugging, water drain, and over-inclination. These last four terms could be considered to be causes of alteration, as they in turn give rise to other forms of alteration.

Examination and photography were carried out with a scanning electron microscope (SEM) for the study of the accretions and mineral concretions produced by microalgae on the original marble. The microscopy was performed with the Electronic Microscopy of the Technical Services of the University of Granada, using the conventional procedures for the DSM 950 Zeiss equipment.

For the study of the chemical elements of the alteration, we used the microanalysis technique SEM-EDX, using images obtained by secondary electrons and back scattering). For this, it was necessary to prepare the corresponding thin slices from samples chosen for element analysis. These slices were carbon coated in a Hitachi evaporator and mounted in the stubs for examination. In addition, other thin slices were made from stromatolite samples for petrographic microscopy (Jena-Zeiss).

As a means of reproducing the environmental conditions existing underneath the mineral crusts and for the identification of the sulphobacteria, four Winogradsky columns [11] were prepared by adding a series of organic or inorganic substrates to the original water that favoured the development of the phototrophic bacteria (Fig. 2a). In each column, 100 g of mud was added, together with 5 g of calcium sulphate, 5 g of microcrystalline cellulose, 5 g of gelatine, mortar, 1 ml of ammonium chloride at 20% in distilled water, and 2 ml of potassium phosphate buffer 0.2 M, pH 7.2. After mixing with a glass rod, the columns were covered with a black cardboard to provide only the appropriate illumination. The involvement of the bacterial cells in the sulphur cycle was determined by the addition of sodium sulphur in the medium and by observation under an inverted light microscope. Highly refringent sulphur accumulations developed in the interior of the cells (Fig. 2b).



**Figure 2:** Winogradsky columns made from purple samples underneath the accretion crusts of Fuente de los Leones, where stratification occurred (a). Micrograph of *Chromatium* 1000x (b).

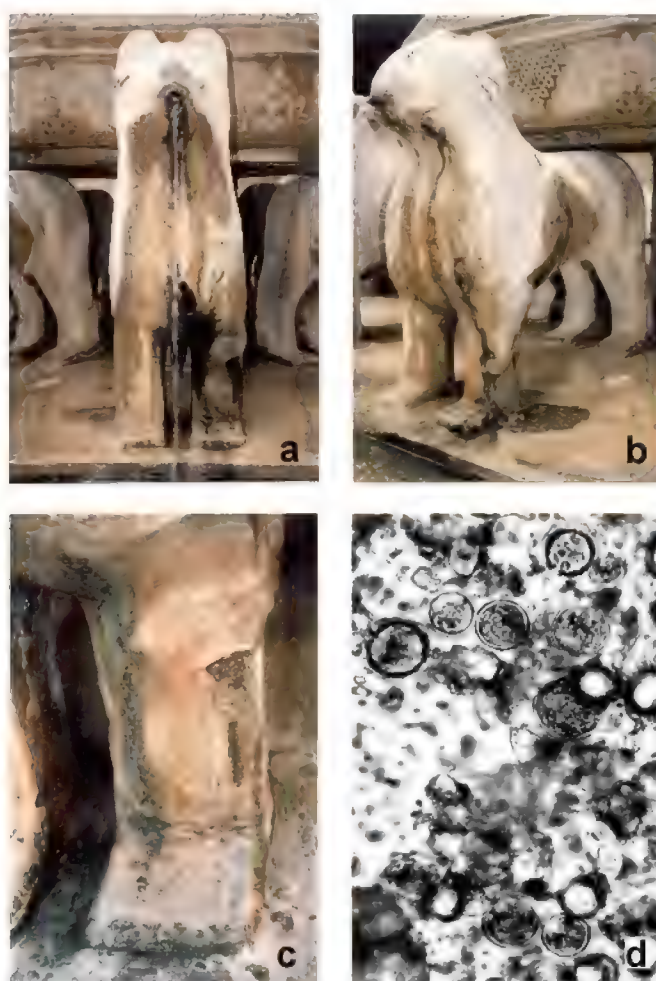
For the identification of the algal species, 86 samples were taken in 22 monthly samplings using a bistoury and cotton swabs as well as formaldehyde at 4% as a fixer. For the most problematic taxonomical groups, cultures were made in solid medium (BBM) and liquid (CHU-10), which in some cases enabled the observation of the complete biological cycle. In addition, small fragments of colonized mineral crusts were cultured to study the development under controlled laboratory conditions.

### 3. RESULTS

Using the terminological glossary for monumental fountains [12-14], we describe the macroscopic forms of deterioration that indicate the state of conservation of the fountains most representative of the Alhambra, referring to the microscopic causes of deterioration.

#### 3.1 Chromatic alterations

Small pigmented surfaces of pine-olive green in colour occur in spring and summer, turning brownish or moss green in autumn and winter. These spots appear in all the zones having pustule communities, principally in the areas of the amphibian biotope of the lions. Many of these are mineralised by splashing and produce extremely compact nodules. Pronounced natural modifications in coloration and/or texture (patina) are highly evident in the areas of spillage (Fig. 3a and b). Some authors [15,16] point out the possibility that originally the fountain was polychrome, but today only an ochre patina can be appreciated, characteristic of Macael marble that has undergone continuous wetting, as occurs primarily when fountains have numerous jets with strong streams. It is possible that the presence of algal cysts (chlorophyta) of a reddish colour (Fig. 3 c and d) have given rise to different theories on the original coloration of the fountain. The fountain presents strata of varying coloration predominantly olive or pine green, comprised of algal communities which are distributed in the wet or submerged parts of the fountain (Fig. 3). In the autumn or winter, the algal films diversify their colours in tones of reds, purples, browns and blue-greens.



**Figure 3:** Patina highly evident in the areas of spillage: a) Lion number 12; b) Lion number 11; c) detail of Lion 12 showing a large crater on the left paw; d) micrograph showing presence of algal cysts (chlorophyta) of a reddish colour which have given rise to different theories on the original coloration of the fountain.



**Figure 4:** Limonitisation occurs on the base of the cylindrical support of the basin caused by water losses. Such losses result from the bad joint of the drain pipe situated underneath of the basin (a). SEM-EDX verified biotransference by algae, bryophytes and bacteria (b).

Limonitisation occurs on the base of the cylindrical support of the basin (Fig. 4a). Here, we verified by SEM-EDX microanalysis the ferrous nature of this phenomenon caused by the oxidation of the drain pipe of the basin, which is made possible by the transference by biological communities (biotransference by algae, bryophytes and bacteria: Fig. 4b).

### 3.2 Crusts

Accumulations of diverse material loosely adhere to the interior of the basin, to the pavement and to the arcade that surrounds the fountain during periods of lax cleaning (surface deposits). And other alterations defined in other of our works such as:

**Accretion:** Precipitation and aggregation of mineral material occur on submerged surfaces, both on horizontal and vertical as well as inclined zones. These are characteristically flat, extensive and of great thickness, in the interior of the fountain (Fig. 5a). The undersides of these crusts usually show a purple film composed of bacteria of the sulphur cycle (family Chromatiaceae), which can give rise to sulphated crusts (Fig. 5b).



**Figure 5:** Precipitation and aggregation of mineral material with algal communities occur on submerged surfaces (a). These are characteristically flat, extensive and of great thickness and usually show a purple film composed of Chromatium (b).



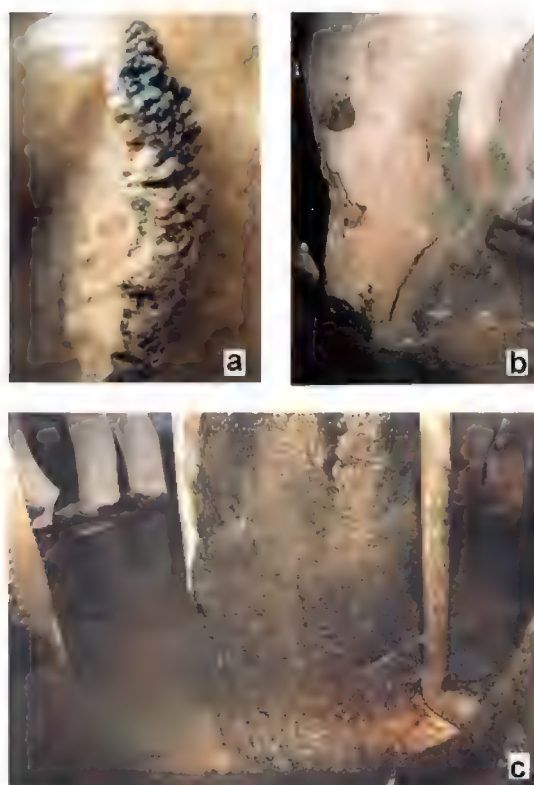
Figure 5: Precipitation and aggregation of mineral material with algal communities occur on submerged surfaces (a). These are characteristically flat, extensive and of great thickness and usually show a purple film composed of *Chromatium* (b).

**Concretion:** These deposits occur primarily on the front part of the lions, due to sprinkling of water from the jets, and on the hind legs (Fig. 3) and the central support closest to the drainage pipe (Fig. 4a). In these two zones, the concretion is nodular and acquires notable proportions. We analysed the layers of more than one cm width. Considerable communities of a dark-green species of moss, characteristic of the natural communities of travertine, were found together with blackish greenish-blue cyanobacteria, green microalgae and diatoms. The algae were colonising extensive thin scales underneath large scales and staining them with a yellowish olive-green colour (Fig. 5). Mineralogical and elemental analyses confirm the predominantly calcareous composition and the presence of aluminium silicate of magnesium, potassium, and iron, with traces of manganese and titanium.

Superficial crystallisation of salts from the interior of the marble (encrustation) have been found at various points of the fountain, as well as a red mineral pigment of unknown origin, which was found on the elbow of one of the lions. This also could give rise to various interpretations, but we believe that, as the coloration is situated in a convex surface, it is most likely due to having rubbed up against another pigmented object.

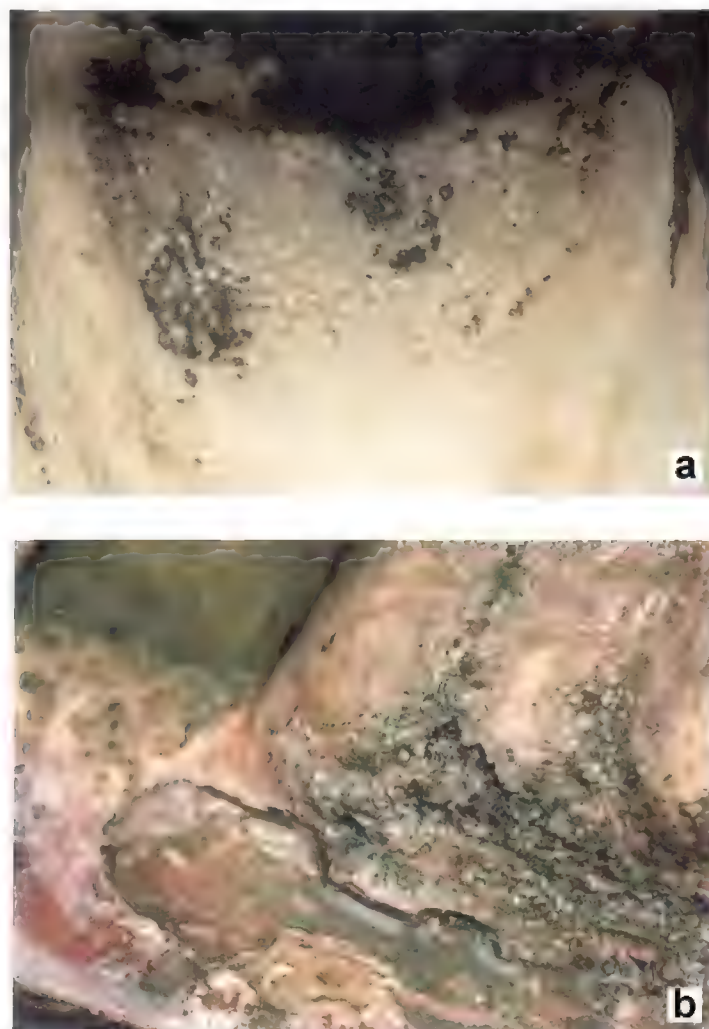
### 3.3 Losses of material

Small cavities appear in many aerial places of the fountain (pitting), the majority probably caused by the pustules of microorganisms: bacteria, fungi, algae (Fig. 6a and b). Notable losses of material create deep concavities in some of the legs and paws of the lions. We have specifically studied the organisms present in a large crater on the left paw of lion number 12 (Fig. 3c). Craters of different dimensions have been caused in the pavement near the lions (Fig. 7a and b).



**Figure 6:** Defects in channelling the water causes alteration morphologies which are highly characteristic of algae and bryophytes associated with spectacular concretions of calcium carbonate and other mineral phases; a): northern side of the central stand; b): great concretion on the hind legs of the several lions; c): Macrograph of this organic-mineral crust





**Figure 7:** Losses of materials with the formation of hollows; a): Small cavities (pitting) appear in many aerial places of the fountain, the majority probably caused by the pustules of micro-organisms: bacteria, fungi and algae; b) Craters of different dimensions have been caused in the pavement near the paws of the lions.

**Faults:** It has been confirmed that the lions have lost considerable amounts of original material, principally from their fronts, faces, ears, legs and especially paws (Fig. 8a-d).

**Excoriation:** By external mechanical action, there are also certain hollows in the fountain, mainly on the surfaces that must be frequently brushed down with biocide and that at the same time undergo the effects of the micro-algal communities (Figs. 8 b and d). Disintegration is readily evident in the heads and paws of the 12 lions, gradually causing heavy losses of material, both deposits and original marble (Fig. 8).

### 3.4 Ruptures

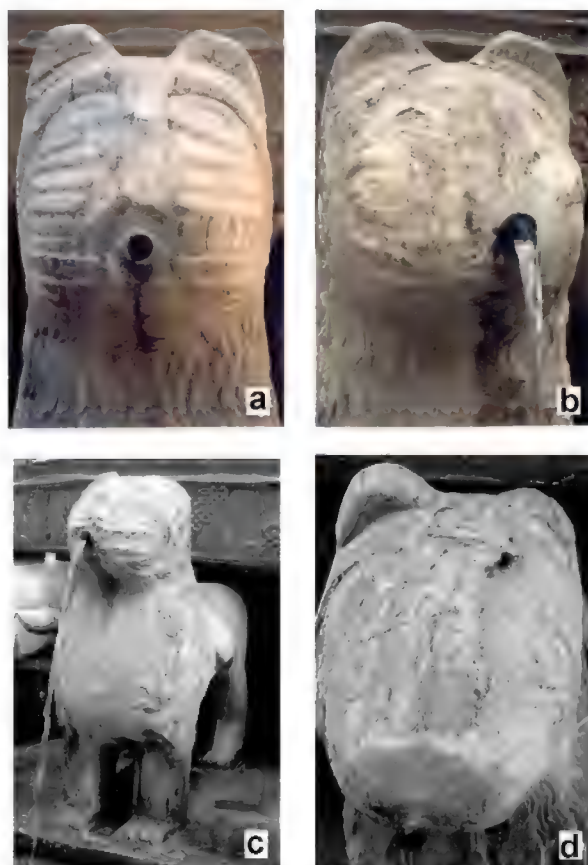
Various types of breaks have been noted, primarily in the lions. As a striking example, we can cite the multiple fissuring visible in the mane of the left shoulder of lion 11 (Fig. 3c). These alterations are aggravated by the presence of chasmolithic algal communities with thick, strongly hygroscopic pods.

### 3.5 Delamination

The lifting up of layers of various millimetres of thickness, regardless of the structure of the stone, is the disjunction most characteristic of this fountain. It appears in most of the lions, especially the most deteriorated ones. In the hind legs, near the large concretions, occur the separations in the thick layers mentioned under the section "concretions" (Fig. 6c).

### 3.6 Malfunction

**Plugging:** Under certain conditions, the lack of maintenance can result in partial plugging of the spouts in the mouths of the lions. This is due to the mass proliferation of photosynthetic organisms (mainly green algae) and deposits which result in greater spillage of water over the surface of the lions due to dripping (Fig. 8 a-d).



**Figure 8:** Faults have been confirmed, principally from their fronts, faces, ears, legs and especially paws; a) head of lion 10; b) Disintegration and desegregation are phenomena highly evident in the heads and paws of the lion 2; c) lion 3; d) head of lion 11.

**Water loss:** Defects in channelling the water can be considered more a cause than an effect, as it causes alteration morphologies which are highly characteristic of algae and bryophytes associated with spectacular concretions, calcium carbonate and other mineral phases (Fig. 6). Such losses result from the bad joint of the drain pipe situated underneath of the basin (Fig. 4a). The escape of water fosters large concretions on the northern side of the central stand and on the remains of an ancient channel, as well as on the hind legs of the several lions, leaving a thick layer of organic sedimentation in the lower zones, as well as colourless nodulations with sharp apices in the highest portions.

## 4. DISCUSSION AND CONCLUSIONS

The state of conservation of the Fuente de los Leones is a complex matter determined by multiple factors. For the physico-chemical alterations, we refer to earlier works [2-4]. In the present work, we focus special attention on the repercussions that photosynthetic organisms have on the conservation of this monument.

As shown above, a great number of alterations in this fountain are related to the presence of algae. Where the algae most proliferate, the deterioration is most pronounced. On the one hand, this is because both factors, alterations and algae, are more apparent where water is most abundant, but a cause-effect relationship between micro-algal communities and the forms of alteration cannot be discounted. In fact, we found that micro-algae and purple sulphur

bacteria were directly responsible for the separation of plates on the interior of the basin, the legs of the lions and the pavement below the fountain.

The first problem in naming the morphology of the alterations which determine the state of conservation of a work of art is the lack of consensus among specialists in this area. Some terms of similar meaning are considered to be synonyms by more synthetic works [5,7,10] or as distinctly differentiated concepts by more detailed authors [9]. This applies, for example to the terms "fissuring," "cracking," "disintegration," "desegregation," or even to differences in the breadth of the concept "patina". That is, while some authors use the term "patina" only for superficial alterations that are difficult to explain and differentiate under other concepts (limonitisation, staining, spotting, etc.), others define several types of patinas: rubefaction, decoloration, soiling, etc. [8]. On the other hand, the restoration of art works in general, covers a vast quantity of terminology, including concepts of encrustation and concretion, among others [17].

In the present work, we have used the term "crust" in the broad sense, which embraces not only the surface modifications of the material itself [7], but also organic or mineral deposits found more or less adhering to the original stone surface. This usage is fundamental in the great diversity of cryptogamic vegetal and bacterial formations, considered together under the term "crusts" and studied in numerous scientific works on epi- and endolithic microclimates similar to those found in our fountains [13].

On the other hand, for ruptures, we have been chosen the concepts of Delgado-Rodrigues [9] on "cracking" and "fissuring," which imply a distinction based on their length (reaching or not the outline of the fountain in question) and not for their spacing or separation. The CNR-ICR [6-7], on the contrary, does not distinguish between these terms.

The terms of concretion and encrustation are sometimes used interchangeably, and other times are considered clearly distinct, and are even subdivided into new concepts (such as "accretion" in our case). Meanwhile, although the term "concretion" is universally accepted, "encrustation" is subjected to major changes in its definition. The CNR-ICR [6-7] considers it to be a stratiform deposit, but only these latter authors emphasise that it can penetrate the surface of the rock. We consider this penetration to be a necessary condition for a meaningful distinction to be made between the terms "concretion" and "encrustation."

In relation to the alterations by delamination, the proposal of Delgado-Rodrigues [9] offers a great variety of nuances: flakes, scales, splinters, platelets, plates, which are distinguished by the extent and thickness of the layer. In this case, as with the CNR-ICR [7], we have found it sufficient for the present study to use only three types: film, scale and plate. In view of the results, both of the study of the state of conservation of the fountains, we can establish certain generalisations. The principal conservation problem presented by the fountains of the Alhambra studied in this work is the insistent appearance of strong concretion, accretion, chromatic alterations and losses of material. In all of these processes, we have confirmed the presence of major algal communities of different composition and structure. Some of these problems characteristic of monumental fountains are cited in the studies made by the ICR of Rome regarding the fountains of that city, but the problematic organisms, because of their complexity, are not known in detail.

With respect to the few results published to date on the state of conservation of the Alhambra, we must underline the difficulty of comparing them in detail to our results, given that previous studies have analysed only the lions of the fountain, and from a purely physico-chemical approach [2,4]. By not conducting a biodeterioration study, these works have not taken into account the action of micro-algae and other organisms which proliferate in these fountains. This approach leads to ascribing responsibility for all the alterations found on the Fuente de los Leones only to thermohygrometric factors, anisotropy of the marble and human activity. The study by Bello et al. [2] did not deal with chromatic alterations, in which the algal activity is clearly evident; rather, the presence of salts (efflorescence) were mentioned as the only type of superficial accumulation, disregarding the importance of the concretions and calcareous encrustation caused by the algae. In this sense, the losses of material and ruptures as well as disjunction are attributed exclusively to human activity, seismically and the presence of salts. Again, the agents of biodeterioration are ignored in the mechanical processes of alteration. The problem does not concern the rigour of the studies, but rather the inter-disciplinary nature of the problems of conservation, which poses serious complications in attending all the disciplines involved.

In summary, we conclude that the principal alterations found in the Fuente de los Leones of the Alhambra involve the chromatic type and the formation of carbonate crusts. The chromatic alterations strongly affect the aesthetic of the white marble of the palaces, which due to eutrophisation proliferate in excess, surpassing the concept of spring water that the Moors conceived for their monumental fountains. The process of carbonation, on the other hand, has repercussions in the examination of the work and can even hamper the reading of the inscriptions on the lip of the 12-sided fountain. Being centuries old, the fountain is highly susceptible to colonisation by organisms, due to the numerous mineral deposits that favour the retention of water and the fixation of those organisms.

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## RUDOLF PÖCH: ANTHROPOLOGIST, EXPLORER, MEDIA PIONEER \*

MARIA TESCHLER-NICOLA *Natural History Museum Vienna*

The scientific project “Rudolf Pöch: **Anthropologist, Explorer, Media Pioneer**” focuses on the comprehensive, albeit fragmented and almost forgotten estate of the Austrian anthropologist, travelling explorer and media pioneer **Rudolf Pöch** (1870-1921). The Austrian scholar was born in Tamopol (Ukraine) in 1870 and died in Innsbruck (Austria) in 1921; he is widely known internationally as a much-travelled scientific explorer. His biography is of particular relevance to the history of science in two ways: On the one hand, for his special interest in comprehensive research and material which he collected at interdisciplinary, large-scale expeditions in the following fields: anthropology, ethnology, medicine, archaeology, musicology and linguistics, as well as botany, zoology, geology and even meteorology; on the other, for his focus on documentation on a variety of state-of-the-art media. He was undisputedly a groundbreaking media pioneer, particularly as far as his early sound and film recordings as well as “field” photography were concerned (Matiasek 2008).

It seems that the trained physician’s interest in anthropology and ethnography was awakened during a medical mission to India, where he investigated the plague in 1897 and which was followed by a training period with Felix von Luschan at the *Königliche Museum für Völkerkunde* in Berlin (1900-01). After another mission to Africa to cure malaria in 1902, he started to plan his own, independent journeys with a research focus on physical anthropology. This led him to New-Guinea, Indonesia and Australia (1904-06) and to the Kalahari desert (1907-09). Upon his return, the experience he gained on expeditions added to his fame as a pioneering expert in anthropology and ethnography. In 1919, he wrote a thesis which made him the first Austrian Professor of Anthropology and Ethnology, and founded the Institute of Anthropology at the University of Vienna in the same year. As an early proponent of the genetic approach, Rudolf Pöch also undertook extensive and controversial anthropological projects in World War I prisoner-of-war camps. He documented his undertakings on a wide range of media that were state-of-the-art at that time (e.g. audio recordings, films and special photographic techniques) as well as in numerous collections (e.g. ethnographic objects and human remains) (Teschler-Nicola 2007a, b; Lechleitner et al. 2006, Lechleitner 2006, 2007).

The project aims to integrate these important objects and media formats, which are now scattered across five Austrian institutions ((*Natural History Museum*, *Austrian Academy of Sciences*, *Department of Anthropology*, *Museum of Ethnology*, and *Filmarchive Austria*) into an internet based, digital database, which will facilitate their critical review by the scientific community. In this regard, we consider our project also a case study of a Virtual Museum, which meets all contemporary requirements for archiving and dissemination of multimedia-based content within a cultural/scientific historical context. We should like to stress, in particular, our intention to repatriate this material by way of digital restitution to the people who had previously been the subject of study.

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# APPLIED TECHNOLOGY IN MUMMIES: CASES STUDIES FROM MUSEUM OF ANTHROPOLOGY AND EGYPTIAN MUSEUM OF TURIN (ITALY)

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## Abstract

New technologies are constantly being applied to ancient remains in order to develop research methods that will generate more information while simultaneously helping to preserve the specimens under study. The studies ranged from research problems and limitations with mummified remains to conservation and application of highly sophisticated technology such as DNA analyses and non-invasive three-dimensional computerized imaging.

From many years, natural and embedded bodies from Museum of Anthropology and from Egyptian Museum of Turin underwent diagnostic investigation with helical computed tomography at the Institute of Radiology of the University of Turin in order to verify the state of preservation and to increase biological and funerary knowledge. Paleoimmunological investigation has provided *Plasmodium falciparum* in Egyptian mummies stored in the Museum of Anthropology.

Regarding molecular biology, in our laboratory has been conducted a molecular investigation of the HbS mutation (presence of sicklelema).

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## 1. INTRODUCTION

New sophisticated technologies are constantly being applied to ancient remains in order to develop research methods capable of generating more information while simultaneously helping to preserve the specimens under study.

The aim of this report is to show some studies that ranged from research problems and limitations with mummified remains to conservation and the application of highly sophisticated technology in mummy research, such as paleoimmunology, paleogenetics and non-invasive three-dimensional computerized imaging. The studies are performed in multidisciplinary cooperation amongst researchers.

Today numerous new malaria diagnostic are available, the immunological investigations lead to new and interesting perspectives in paleopathological studies.

Regarding molecular biology, the detection of ancient microbial DNA offer a new approach for the study of infectious diseases, their occurrence and host. Moreover, the data that are obtained from the skeletal and mummified tissues may represent an important completion of contemporary phylogenetic analyses of pathogens. In particular. The study of microbial DNA in ancient remains contributes to the understanding of transmission and spread of infectious diseases, and potentially to the evolution and phylogenetic pathways of pathogens (Zink, 2002 ).

Regarding paleoradiology, from many years, anthropologists, paleopathologists and radiologists of the University of Turin performed non invasive studies on ancient natural and embedded bodies, housed in the Egyptian Museum and in the Museum of Anthropology of Turin. Twenty Egyptian mummies underwent diagnostic investigation with helical computed tomography at the Molinette hospital in Turin. Helical CT represents an accurate method of non-invasive evaluation in order to verify the state of preservation of the bodies and to increase biological and funerary knowledge.

## 2. MATERIAL

### 2.1. Paleoimmunology and paleogenetics

These studies was conducted on ancient Egyptians human remains housed in the Museum of Anthropology and Ethnography of the University of Turin. The Museum holds one of the largest and most important Egyptian collections of skeletons and mummies. This assemblage was recovered during the archaeological campaign in Egypt at the beginning of XX century under the direction of E. Schiaparelli, Egyptologist of the Egyptian Museum of Turin, with the collaboration of G. Marro Anthropologist of the Museum of Anthropology of Turin. The human remains come from the necropolis of Assiut and Gebelein, located along the middle course of the Nile.

For the paleoimmunology study, we analyzed 80 human samples (mummified tissues and bones) belonging to Predynastic and Dynastic period.

Paleogenetics analyses was conducted on a selection of 6 subjects from Predynastic period. We assessed the state of preservation, with the exception of embalmed mummies because chemical compounds, used for embalming, can insert in the DNA molecule or inhibit the PCR.

## 2. 2. Multidetector Computed Tomography and 3D Reconstructions

Between 2001 and 2006 twenty Egyptian mummies, housed in the Museum of Anthropology and Ethnography and in the Egyptian Museum of Turin, were transported from the Museums to the Institute of Radiology of the University of Turin (Molinette Hospital). The historical collection of anthropological and zoological specimens housed in the Egyptian Museum of Turin dating back to the 19<sup>th</sup> but received significant increase during the Italian Archaeological Mission directed by Schiaparelli from 1903 to 1920, and by Farina up to 1935, with the collaboration of Giovanni Marro. Most mummies come from the necropolis of Assiut and Gebelein (De Lorenzi e Grilletto, 1989; Grilletto, 1991).

The mummies analyzed are complete, wrapped or natural, and in good preservation condition.

For each mummy a single volumetric acquisition of the whole body was performed.

## 3. METHODS

### 3.1. Paleoimmunology

*Plasmodium* parasites synthesize several proteins. Some of these proteins have been sequenced, cloned and used for diagnostic kits based on the ELISA immunoenzymatic assay. This technique was created for blood samples.

We used two kits for qualitative detection, making some modifications for the study of ancient remains like mummified tissues (skin, muscle), bone and dental samples.

The characteristics of the diagnostic kits are:

*ParaSight-F test*: immunoenzymatic assay detecting histidine-rich protein 2 (a water-soluble protein released by erythrocytes parasitized by *P. falciparum*).

*Optimal test*: revealing *Plasmodium* lactate dehydrogenase (an enzyme produced by the parasites) able to differentiate among *P. falciparum* and non-*falciparum* malaria (Cerutti et al., 1999, Rabino Massa et al., 2000)

### 3.2. Paleogenetics

The aDNA was extracted from dental samples (500 mg). To prevent contamination with modern DNA, the external surfaces of the teeth were washed with a hydrochloric acid solution. All the reactions were carried out in sterile conditions and pre- and post-PCR work was performed in separate laboratories.

We applied a silica-gel method specific for ancient remains, which purifies the DNA by removing components inhibiting amplification (Höss et al., 1993)

To amplify the DNA, we employed the *Amplification Refractory Mutation System* (ARMS), with appropriate modifications to adapt the method to ancient DNA.

ARMS permits the diagnosis of single nucleotide substitutions and it is based on specific priming of the PCR. In this method, amplification can occur only in the presence of the specific mutation being studied. This technique can be very useful in the study of genetic diseases: once it has been verified that the operator's DNA does not contain the mutation, any possible contamination cannot influence the result of the amplification.

The amplified products were analyzed by electrophoresis in 2% agarose gel. In the series of samples, we included modern DNA controls for HbS (negative and positive) and a control to monitor contamination (PCR without extract). (Marin et al., 1999)

### 3.3. Multidetector Computed Tomography and 3D Reconstructions

A helical computed tomography scan were performed on the bodies with acquisition on a digital radiogram (scout view) A multidetector CT unit (Lightspeed Qx/i; General Electric Medical Systems, Milwaukee, USA) with the following scan parameters was used: 120 KV, 200 mA, scan time 0.8 sec., slice thickness 2.5 mm, reconstruction interval 1.25 mm, High Speed modality, bone and standard algorithms. Post-processing, with evaluation of all the axial images and multiplanar and 3D reconstructions, was carried out at two workstations: Precision 530 with 2.5 Vitrea software (Vital Images, Fairfield, IA) and Sun Workstation (Advantage Windows 4.2, General Electric Medical Systems).

## 4. RESULTS

### 4.1. Paleoimmunology

As shown in previous studies the immunological test is suitable for ancient remains (muscle, skin and skeletal samples).

The specificity for antigen HRP 2 is high. This protein remains unaltered for a very long time. In fact, the specimens are very ancient, some of them dating to more than 5000 years ago.

The Egyptian collections are particularly suitable for immunological studies, since the taphonomic conditions were rather good for the preservation of proteins, except for exposure to excessive temperatures (over 50°C). Indeed the

affinity for histological stains, used for decades on sections of mummified tissue, show the generally good status of the specimens.

The mummified remains were positive to the immunological test for *P. falciparum* in 42% of the cases

In order to recognize other *Plasmodium* species, we applied the *Optimal test* kit. However, the results were negative for all samples. This disagreement may be due to the inability of this assay to reveal unviable parasites. In fact, the *Optimal test* kit recognizes an enzyme produced by the living protozoans, no longer present in the ancient remains (Cerutti *et al.*, 1999, Rabino Massa *et al.*, 2000).

#### 4.2 Paleogenetics

The results of the analysis of ancient DNA have been presented and discussed in a previous paper (Marin *et al.* 1999). The samples were in a very good state of preservation and we could extract a sufficient quantity of non-degraded DNA.

Some of the electrophoresis runs of the agar gel are reported in the Figure 1.

These preliminary results indicate that the DNA extracted with the Invisorb® Forensic Kit I was successfully amplified with the CLONIT KIT for four mummies.

The three amplifications products, that were nor visible, were dried and resuspended in low TE and submitted to electrophoresis again. In this way another sample showed a band of 169 bp. The positive control, that is indicated in the red circular line, was extracted from the fresh blood of a patient with malaria diagnosed by an immunological test (Amedeo di Savoia Hospital in Turin).

The amplification was not performed in the laboratory where the ancient DNA was analysed.

The phenol chloroform and the chelex extraction were not successful and they gave inhibition in amplification.

The specific identity of the PCR products will be verified by sequencing the fragments and they will be compared with the sequence of the 18s rRNA gene of *P. falciparum* and other organisms.

The investigated subjects exhibit extensive bone pathologies characteristic of severe anemia. In the electrophoretic analysis, three individuals showed amplification products after ARMS for the hemoglobin S mutation, indicating the probable presence of sicklelema.

The discovery at the molecular level of this mutation in the mummies of Gebelen not only supports a paleopathological interpretation previously proposed by E. Rabino Massa (1977), but is also of great anthropological interest. In fact, this hemoglobin variation is distributed in polymorphic proportions (over 1%) in North African populations and is a valid anthropogenetic marker. It also highlights the great potential for the use of these new molecular investigation systems in paleopathological diagnoses of genetic diseases, viral, bacterial, protozoa, fungal infections and metazoa infestations.

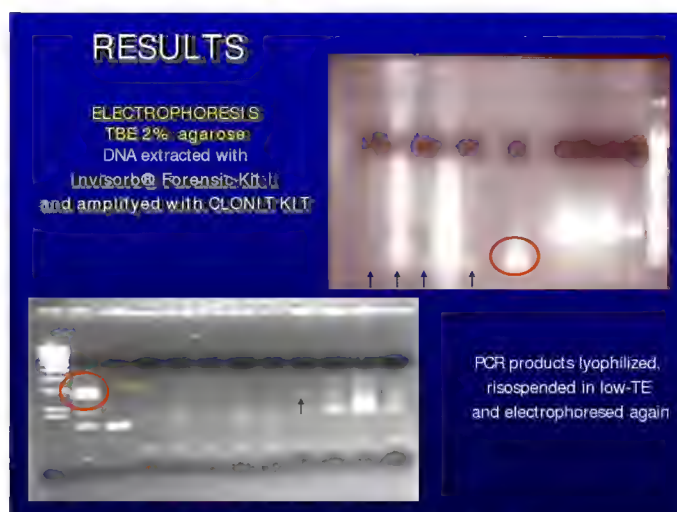


Fig 1 - electrophoresis runs of the agar gel

#### 4.3. Multidetector Computed Tomography and 3D Reconstructions

CT study allowed a careful evaluation on the general condition of bodies, embalming procedures, amulets and jewels, anthropometric data, age, pathologies; moreover, structures with different densities can be identified, in particular soft dehydrated tissues, residual organs, visceral packages and some foreign bodies that cannot be depicted on conventional X-ray studies because of their low density (Boano *et al.*, 2009; Cesarani *et al.*, 2009, 2005a; 2004; 2003; Martina *et al.*, 2005; Pedrini *et al.*, 2005; Bianucci *et al.* 2005), Fig. 2. Three dimensional multidetector CT examination was also used in order to reconstruct the possible physiognomy of ancient mummies (Cesarani *et al.*, 2004, 2005b).

Among the studies performed recently by our laboratory, we underline the study of the mummy of the architect Kha, belong to XVIII Dynasty, one of the most important mummies housed in the Egyptian Museum. From



anthropological point of view, Kha died at the age of approximately 60 years, he was probably fat and radiological features showed the presence of dehydrated brain tissues and other internal organs. Inside bandages, the presence of metal, very likely golden collar, earrings and bracelet and other radiopaque amulets such as scarab on the chest and Isis knot on the front were carefully identified and reconstructed with post-processing. From paleopathological point of view, the CT scan study revealed signs of arthrosis in the spine and knees, many arterial vessels show diffuse calcifications (Martina *et al.*, 2005) and gallbladder stones was identified and well described (Cesarani *et al.*, 2009).

Once more Ct, especially supported by new post-processing techniques, confirmed its fundamental role in the non invasive study of the interior of ancient mummies.



**Fig. 2 a,b** - a) Egyptian mummy from Dynastic period (Museum of Anthropology and Ethnography of Turin).

b) Radiological analyses on the same mummy performed at the Institute of Radiology of the University of Turin (Molinette Hospital).

## 5. CONCLUSION

In recent years, the study of mummified remains has attracted the attention of the general public and researcher of different cultural extractions for new interpretations which, far from being of sterile scientific curiosity, are of great anthropological and paleopathological interest and help to enrich our knowledge of the biological history of the man. We can read in mummies not only our history but also a significant part of our future. For instance, the study of past diseases can contribute to the epidemiological interpretation of current ones. Turin has a long tradition of anthropological studies of ancient populations, particularly Egyptians because of the many collections of mummies and skeletons that have enriched the Museum of Anthropology and Egyptian Museum. These collection assume the important role of biological archives and permit the integration of historical data with those from bioanthropological research.

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## SESSION C2 - PERFORMING ARTS

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### PHOTOGRAPHY AND CINEMA IN THE MEDITERRANEAN

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<sup>2</sup> *The contribute of Maurizio Zignale is referred to § 2*

#### Introduction

The Mediterranean, a cross road of people, is the union of different identities coexisting in this large region. It has been treated under any aspect, both scientific and cultural, and either cinema and photography have given a real effort to the knowledge of a so different area both economically and culturally, but close and joined in the expressive shapes of the arts. First we must clarify the physical limits of the Mediterranean Area, as a concept often generalized.

This Area is geographically identified with the Mediterranean Sea, so called, “*Mare Nostrum*”, and with countries which face on it. We have also to consider the landscape with its cultivations and its peculiarities given by almond tree, olive tree and vine plant. The Mediterranean has always been a favourite destination for travellers, writers and photographers. The reasons are linked to the historical and cultural richness of the Mediterranean Area. Photographers chose this latitude because of natural light set-up, as analogical cameras needed a wide light source, the contrast between the sky and the landscape, and for the discovery of exotic places. As Grand Tourists told about classic ruins, different behaviours, and naturalistic landscapes, so photographers want to discover and tell through images marvellous archeological ruins, like Pyramids, Greek and Roman structures, beautiful sands, wide natural open spaces and the desert.

#### 1. Photography in the Mediterranean

After a pioneeristic phase, as soon as technical progress permitted, photography began a professional documentary for describing societies and cultural heritage. One of the most important photographers, that followed this path, was Felix Bonfils, who aimed to create a systematic census of the state of preservation of archeological sites. With his wife, Lydie Cabanis and his son Adrien he settled in Beirut in 1867 and opened a photographic studio that became one of the most important in the Orient. In 1871 he had already taken “591 negatives in Egypt, Palestine, Syria and Greece, and also 9000 stereoscopies”, for which he had used several cameras even when he went into places as dangerous as Baalbeck or Palmyra. The importance of his work lies, above all, in the systematic census of the state of preservation of the sites that lasted for over ten years, and was continued by Lydie and Adrien.

Frank Mason Good represented local people portraits in their traditional costume, which was unusual and difficult for creeds of that period. He was active in the Middle East during the 1860s and also made a further visit to the Holy Land during 1874. Almost no contemporary sources are available on this photographer who undoubtedly ranks as one of the most important photographers for having worked in the Holy Land.

Ya'Acov Ben Dov was born in Ukraine and as a dedicated Zionist immigrated to Eretz-Israel in 1907. He was tirelessly involved in the building of the yishuv (Jewish settlement of the land) and in recording photographically many events that took place. He knew all the Zionist leaders, and his home was often the scene of heated political discussions. He photographed many of these leaders and artists as well as famous people connected with the founding of the Jewish homeland. He died at the age of 86, having lived to see the reunification of his beloved Jerusalem where he lived.



**Fig.1** Camels in desert - Felix Bonfils

Gustav le Gray, dedicated his photography both to reportage and landscape, impressing, for the first time, the Mediterranean Sea. He began to tour the Mediterranean in 1860 with the writer Alexandre Dumas. His photo of Garibaldi and Palermo under Sicilian bombing became instantly famous throughout Europe. Le Gray went to Lebanon and Syria; in 1864 he decided to establish himself in Cairo where he remained about 20 years, earning a humble life as drawing teacher, while still having a small photography shop. His passion for the sea is expressed in some images of the Mediterranean, the first in the world, sold at an auction for 2.000.000 €.



**Fig.2** Brig on the water - Gustav Le Gray

In later seascapes such as *The Great Wave* (1857), Le Gray would famously resolve the problem of capturing both ocean and clouds by printing his seascapes from two negatives—one exposed properly for the shore and sea, the second for the sky. This first essay, however, was made with a single negative and succeeded by taking advantage of the reflective qualities of sea, as opposed to land, and by suggesting the effects of twilight or moonlight rather than bright daylight. *Brig on the Water* was among the most famous and widely distributed photographs of the nineteenth



century, enjoying enormous success in England as well as in France. A London printseller's advertisement in *The Times* in November 1856 made the incredible claim of "800 copies subscribed for in two months."

Beato brothers, Antonio e Felice, during their trips, described the originality of Mediterranean people. Antonio Beato is noted for his genre works, portraits, and views of the architecture and landscapes of Egypt and the other locations in the Mediterranean region. He was the younger brother of photographer Felice with whom he sometimes worked. Until 1900, they undertook numerous trips and produced a complete catalogue of Egypt. After collaborating with his brother Felice in India, Antonio settled in Cairo, and then in Luxor, where he took photos for tourists.

Francis Frith was one of the first photographers who started to take picture about landscape and monuments from different angles, putting a valid element to give a mental proportion of the image. Editor and photographer, he published in his lifetime more than 10000 views. Founding member of the Liverpool photographic Society, since 1855 he will be devoted only to photography. Between 1856 and 1870, with his assistant Frank Mason Good, Francis Frith undertook numerous trips to Egypt, Syria and Palestine, producing a complete catalogue. After the second expedition, in 1859 he founded a publisher "Francis Frith & Co" (active until 1960) creating photo books about the countries of central Europe.

Catalogues from these photographers and many others, show the "miraculous" moment of the discovery of the Mediterranean through photography. Words can never adequately describe the difficulties they encountered and the risks they run during their trips, but their works have permitted to reach the masses, establishing a new relation between photography and people, who initially distrusted it. We have to remind that in the east Mediterranean, iconographic representations were forbidden by religion until the second Nicea Council. Catalogues from these photographers, show the "miraculous" moment of the discovery of the Mediterranean through photography and represent the variety of natural and cultural heritage.

Nowadays photographers look at the Mediterranean under several approaches linked to the serious economic and social situation faced by the populations.

Immigration, as the first emergency in the Mediterranean area, is often taken into consideration by many photographers who try to reveal its worst aspects. There are many private associations and NGOs that promote this photography as an important tool to show to the world Mediterranean illegal immigration and inhuman conditions of migrants.

Many Mediterranean countries are affected by the scourge of civil wars often caused by religious extremism. The documentary photography has an important role in the information process that interests these events. Many photographers and video makers lost their life for reporting these human tragedy.

Photography has several branches, one of these is the touristic photography, a completely different field comparing to the ones explained before. Especially, it aims to show cultural and historical attractions, advertise local touristic services and promote the territory to encourage investment on it. So the prerogative is to create an attractive image of the product, including the territory itself.

Sometimes this kind of photography represents some stereotyped shapes relating to the territory and culture, therein, it constitutes the main weakness of this approach.

Another specific branch is the movie still photography; photographer usually works on set but is not directly involved in the making of a film. His role is to publicize, through his pictures, film and actors on magazines, newspapers and other media. On set photography and cinema converge on the same direction, giving to images a functional value: descriptive and emotional, in the same time.

## Introduction

Cinema, better than photography, represents the ideal link between the emotional sphere and the territorial dimension. Cinema has always aroused spectator feelings, moving him, through scenes, to an imaginary journey. So, spectator can get inside one's character, location and time of film narration.

Modern traveller aims to visit locations watched on movies creating a new tourism frontier, called movie induced tourism. Film tourism is a growing phenomenon worldwide, fuelled by both the growth of the entertainment industry and the increase in international travel.

Today the Mediterranean region represents the right correlation between supply and demand in film tourism.

## 2. Cinema and Movie Induced Tourism in the Mediterranean

Movie induced tourism generate several activities linked to the promotion of locations as, a proactive effort to encourage producers and studios to film at the location; media publicity around the film and its location; marketing activities promoting film location after production; peripheral marketing activities to increase film tourism potential. The actors of this phenomenon are: Film Commissions, Product Placement Agencies, local Government and Film Production. Film Commission represents the missing ring between local Government and film Productions. Each country of the Mediterranean, has its own film commission like, Egypt, Jordan, Israel, Italy, Libya, Morocco, Spain, etc. etc.

Film commission has specific roles, consisting in Provision of detailed and fast information about filming in the Country; assistance in obtaining necessary bureaucratic permits; assistance in location scouting with knowledge of

all locations; assistance in customs clearance for technical equipment; assistance in casting and recruiting local crew and extras at competitive rates; facilitation access to production services, facilities and equipment; liaison with private and public sector entities; provision of financial facilities. The most important film commissions of the world have different histories and evolutions.

American film commissions, founded in the 40's, represent some of the oldest expressions of the combination of cinema and territory in the States.

For decades, the motion picture and television production industry has been a cornerstone in America's creative economy.

In the last report (2009) of Motion Picture Association of America, 2.5 million Americans jobs are supported by the motion picture and television industry; over 115,000 businesses in all 50 states (81 percent of which employ fewer than 10 people) and their economies are increased by on-location production, infrastructure development and movie and television-related tourism; it carries a positive balance of trade around the world and a \$13.6 billion trade surplus.

These data show how the economic value of the cinema industry contributes on the GDP (Gross Domestic Product). In 2006 the Journal of Travel Research revealed that a location depicted in a movie could increase its incoming tourism of 75%.

Mediterranean countries should learn by the American experience, taking into the account the opportunities of this field.

In view of these data, many Mediterranean film commissions are offering benefits to encourage foreign film productions to invest in their locations; for examples in Israel, the Law for the Encouragement of the Production of Films was approved by the Israeli Knesset on October 28<sup>th</sup>, 2008. The main aim of the law is to encourage the production of foreign films in Israel. To this end the law offers generous tax benefits that reduce the cost of production up to 20% and recognizes two models, Foreign Productions and Co-Productions.

Film Commission Ouarzazate – Morocco is an initiative among the Italian Istituto Luce and Regione Lazio, showing, so, the importance of this kind of collaboration with foreign public bodies and private industries. In Italy, Greece, Spain and in different Mediterranean countries, there are many regional and local Film Commissions to demonstrate the importance of this specialized tool. Moreover, many events are organized to promote territory, like Film Festival, to convince foreign productions to invest in their countries.

Another significant contribution is given by the Product Placement Agencies, that they raise an important relation between film productions and companies from several fields, they introduce new investment typologies representing the keystone for the active involvement of the economic fabric to the film production. This agencies focuses the film peculiarities (setting, period, and so on...) in order to identify potential partner companies. The second step consists in the mediation between film productions and companies, in this activity needs a good collaboration between screenwriter and producers in order to find the best way to introduce advertising products into the film narration. So it's important to say that movie induced tourism produces different impacts on filmed locations:

- direct economic impact;
- socio-cultural impacts on the residents and on the spectators too;
- image modification (enhancement) impact: Film as a promotion tool, even if, sometimes, some themes treated and showed in a wrong way, as mafia, terrorism, religious extremism etc. etc, generate a negative promotion, enhancing the perceived risk of the location;
- promotional effects after film projection on cinemas.

Movie induced tourism moves a lot of visitors and for this reason it's important to develop appropriate tourism infrastructures, to involve local communities, forming qualified personnel, to create a new tourism consciousness linked to the film.

Movie induced tourism develops significant changing in the territory configuration, many socio-cultural aspects, generating different feedbacks that involve people in their sense of belonging or rejection. So, many local Government are introducing some limits to the uncontrolled tourism incoming, in order to preserve their locations and their customs.

Today, this represents the first step for the sustainable concept into the movie induced tourism. In the last five years, many Mediterranean regions are focusing their economic efforts to enhance this kind of tourism. Looking at the cinema panorama in the Mediterranean, there are many films set on these territories like:

- Morocco with The Mummy 1 and 2, Spy Game, The Gladiator, Black Hawk Down;
- Tunisia with Star Wars, The English Patient and the recent Baaria;
- Jordania with Mission to Mars, The Mummy Returns, Redacted;
- Greece with The Bourne Identity, Mediterraneo, My Big Fat Greek Wedding;
- Spain with All about my Mother, The Spanish Apartment, Volver;
- Italy with The God Father, Star Wars, Ocean's Twelve, The Passion;
- Israel with Schindler's List, Waltz with Bashir, Lemon tree;
- Egypt with The Awakening, Death on the Nile, Malcom X.

These films represent some of the hundreds of movies, set on Mediterranean countries. Learning by American and Australian experiences, Mediterranean countries should focus more attention to the movie induced tourism, investing more financial resources to develop both social and economical aspects, so promoting, at the same time,

their own cultural and territorial identities. Cinema and, especially, movie induced tourism, could represent the *leit motive* to destroy all the barriers around the world, opening new good relationships among Mediterranean countries.



Fig. 3 Poster Spy Game



Fig. 4 Poster The Mummy



Fig. 5 Poster Lemon Tree



Fig. 6 Poster Gladiator



Fig. 7 Poster Waltz with Bashir

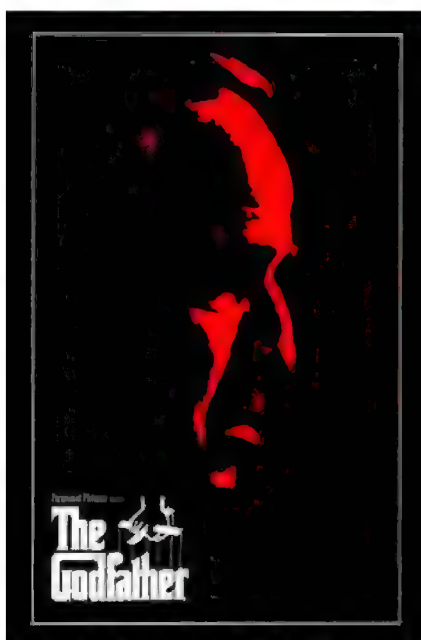


Fig. 8 Poster The Godfather



Fig. 9 Poster Redacted

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- [www.mpaa.org](http://www.mpaa.org)



# SEARCHING AND BROWSING FILM ARCHIVES: THE EUROPEAN FILM GATEWAY APPROACH<sup>1</sup>

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**Keywords:** Video Archives, metadata, film, content-based search, semantic content description

## 1. Introduction

Several countries and film archives are doing significant investments in digitizing existing collections of moving images and cinema-related material (audio documents, photographs, posters, drawings, text documents). At the same time, there is a significant growing interest to have access to film repertoire, composed of movies, documentaries, scientific videos, and all the material related to them, while existing tools and services do not offer a simple and complete access to the videos that are becoming available. This is due, on one side, to the poor description of the videos, and on the other side, to the limited capabilities offered by search and access services. In many cases, videos are described by using very limited information, such as title, author name, etc.. Furthermore, descriptions available in different archives are very different so that it is difficult to have a uniform access to videos coming from many different archives. Finally, the values used to describe videos, e.g. person names, places, film names, etc. are not taken from unique authority files, so that when these data are used to search videos, many relevant items are not retrieved. Another relevant issue is related to the need of efficient tools that simplify the process of query formulation – possibly including multilingual access – support for browsing of relevant object, and effective presentation of retrieved object.

All these requirements conducts to recognize the need for a precise strategy for interoperability between different archives, which supports interoperability at the level of the format used to present object descriptions as well as at the level of its semantic description. This means that we need a metadata schema that is powerful enough to describe the richness of film content, but at the same time is flexible enough to support interoperability of existing archives through a simplified conversion of existing descriptions into the common schema. At the same time, it is necessary to have the possibility to define common authority files for the most relevant metadata elements, and to have the possibility of cleaning the data coming from different archives by using the authority file values.

This problem has been addressed within the EFG (European Film Gateway) Best Practice Network<sup>2</sup> funded by the European Commission under the eContent<sup>plus</sup> programme<sup>3</sup>. The Project started on 1st September 2008 and will have a 3-year duration. It currently assembles 21 partner institutions from 15 European countries and aims at building a single access point to digital collections of film institutions in Europe. As an aggregator project towards the European Digital Library, EFG aims at enabling Europe's film archives and cinémathèques to contribute their rich and valuable collections to Europeana<sup>4</sup>. It aims to provide direct access to more than 700.000 digital objects including films, photos, posters, drawings, sound material and text documents.

## 2. Overview of problem solution

The metadata schema should be able to describe at a sufficient level of detail many different types of information, ranging from audio/video objects to non audio/video material such as images, posters, documents, etc. as well as persons, events, access rights. Furthermore, the model must support the description of relationships between different elements. It is also required that importing data from different archives is simple, fast, and without loss of details in the description. The model should allow one to describe the content of each digital object, as well as information about the owner of the object, the property rights for its use, who are the persons or companies involved in its creation, etc.

As already underlined, user satisfaction and the success of any service that will use these data would require a significant number of digital objects available, but also an high data quality, which means high video quality, and uniform metadata values certified by experts. High video quality is guaranteed by the adoption of standardized ways for digitalization, high bit rates, and the use of standard video formats. Uniform metadata values become possible if the system adopts and enforces the use of authority files for the most important metadata values.

A third issue is the need of a specific tools that supports the access to the videos, based on their content. A specific requirement that derives from the integration of different archives in many countries, is that multilingual searches must be supported.

All these issues have been addressed in the EFG Project [2]. Our first activity consisted in the definition of a metadata model which supports all requested needs. The model will be described in some detail in the next section. In order to support interoperability with other archives, i.e. the possibility of importing and exporting metadata and multimedia objects from and to external archives, we developed a specific conversion module from native archive formats into the EFG metadata format and from the EFG metadata format into OAI-PMH [3]. The first component, which has a part that is archives-dependent (i.e. is we need to import data from a new archive, a new component must be implemented), maps each native metadata element into one of the EFG metadata elements. The definition of mapping rules requires the knowledge of the native archive format, apart that of the EFG metadata format. The

module that supports the export of metadata represented in OAI-PMH, offers the possibility of transferring the data from the EFG archive into any other archive that accepts data represented in OAI-PMH. In particular, in the Project we will ingest most of our data into Europeana [4], so that the rich video archives can be accessed through the portal of the European Digital Library.

As soon as data are ingested into EFG, they must be “cleaned” and validated before making them available to end users. The cleaning process makes use of a set of thesauri and controlled vocabularies that are used to convert original data values into uniform values. During this phase, if an archive is ingesting a movie with the name of an actor that is not present into the authority file, the system will propose, by using similarity criteria, one or more possible alternative values. The archivist can either accept one of the proposed values, or he can decide to extend the thesauri with the new name. During this phase, the system detects possible connections between the new ingested item and those already existing. All these relationships are verified by the archivist for final approval. Finally, the archivist can create new relationships between the new items and those already present in the archive. All these functionality are offered through a tool for the management of authority files and metadata editing.

After completion, all validated data are ingested into the archive and made available to end users. The archive is based on the D-Net storage service [1]. The system foresees two different user categories: the archivist – who has the possibility to search all objects archived and to edit their descriptions, if necessary – and the generic user – who has the possibility to search, to browse the archive, and to visualize its content (including videos) through a web portal.

Finally, since the interoperability with other systems and platforms is one of the key issues addressed, the system offers the opportunity to export any object or groups of objects by using the OAI-PMH protocol.

### 3. The EFG metadata schema

The main step in building the strategy described in previous section is given by the definition of a common metadata schema to which the proprietary schema of the EFG content providers, and later on other schema, could be mapped. In order to do this, we took three specific requirements into consideration:

1. The need to meet the specification of the user requirements. These provide an indication of the concepts that are required by the user and the relative importance of those concepts.
2. The need to represent the concepts that are present in the data. By examining the data it is possible to determine the issues that arise when representing concepts relating to film objects.
3. The need for interoperability. It is necessary to be able to map from content provider legacy metadata to current

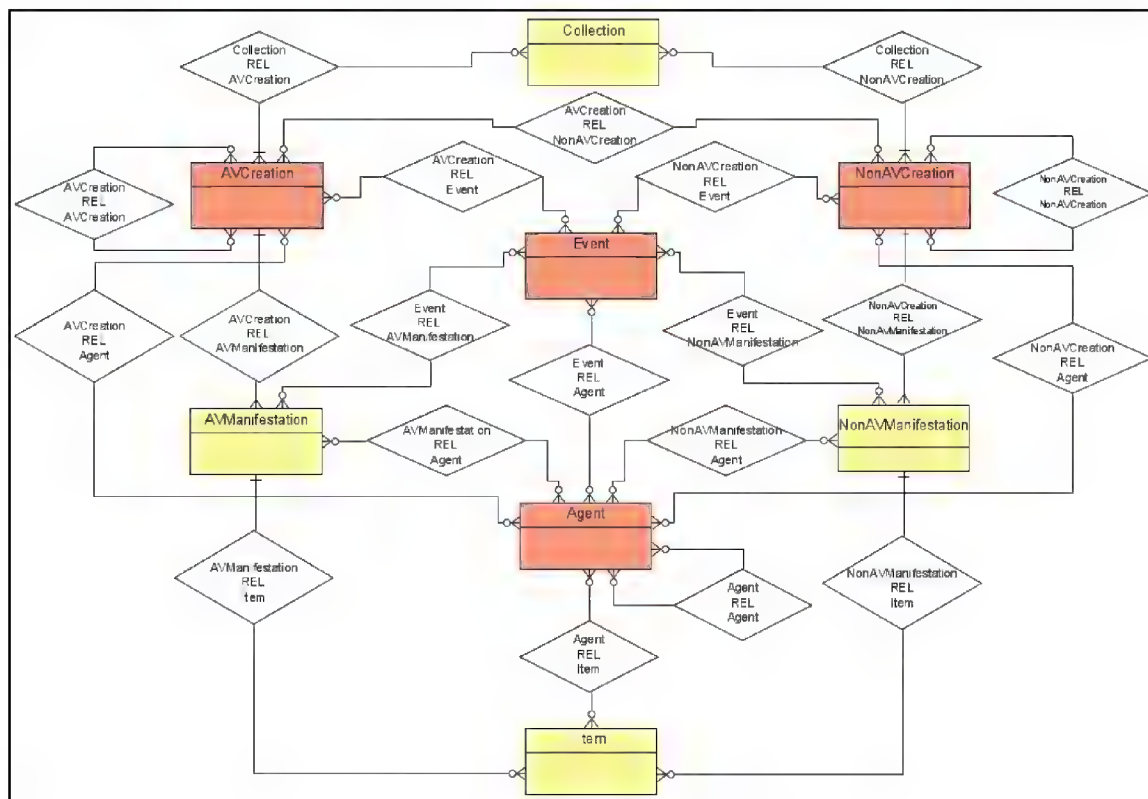


Figure 23 - Structure of the EFG metadata schema

“standard” metadata schemas.

This schema is the result of a study of the metadata schemas and semantic resources widely used within the organizations belonging to this specific domain as well as an analysis of the content and associated metadata to be

used in the project, as selected by the Content providers of the EFG consortium. This study took into consideration standards such as FRBR and Dublin Core, the Europeana schema as well as more film-specific standards as the evolving Cinematographic Works Standards EN 15907.

The EFG schema is composed of eight major entities, which are defined as the topmost level of description that can have relationships to other entities. In order to describe objects, the EFG metadata model basically distinguishes between three levels: Creation, Manifestation and Item. “Creation” is the topmost level of description, which can be either an audiovisual work (represented in the “AVCreation” entity) or a non-audiovisual work (represented in the “NonAVCreation” entity). This applies also to the “Manifestation” level which is represented in the entities “AVManifestation” and “NonAVManifestation”. The “Item” entity functions as a logical wrapper for the digital file presented in the EFG portal. Moreover, “Agents”, “Event” and “Collection” also have entity status.

Each major entity of the schema comes with elements, attributes and relationships. Figure 23 illustrates all entities represented in the model and the relationships that may exist among them.

In particular, the eighth main entities of the EFG schema<sup>5</sup> are as follows:

- The AVCreation contains the properties of a cinematographic work. For example, it includes the film title, the record source, the country of reference, the publication year, etc.
- The AVManifestation contains the information about the physical embodiment of an audiovisual creation. Examples are archival copies (analogue or digital) and database files. Examples of the AVManifestation properties are again Title, Record Source, and Language, as well as Dimension, Duration, Coverage, Format, Rights Holder, and Provenance.
- The NonAVCreation describes all non audiovisual creations that can be represented in EFG. These *are pictures, photos, correspondence, books or periodicals*. The *properties* of NonAVCreations are Title, Record Source, Keywords, Description, Date Created, Language.
- The NonAVManifestation has the function to keep track of copies made of non-audiovisual objects. It has properties such as Title, Record Source, Type (e.g. text, image, sound), Specific Type (e.g. photograph, poster, letter), Language, Dates (i.e. a date or period associated with the issue of the manifestation), Digital Format (including its status, size, resolution), Physical Format, Geographic Scope, Rights Holder.
- The Item entity points to the digital file held in the source repository. Its attribute are isShownBy (i.e. the URL references to the digital object on the content provider’s web site), isShownAt (i.e. the URL reference of the object in its information context), Digital Format, Provider, Country.
- The Agent is defined as an entity that can perform an action. The model includes three agent types: Person, Corporate Body and Group. For example, the Person Agent has the following elements: Name (which includes one or more Parts, such as the prefix, the forname, family name, etc., it also include the geographic and temporal scope), Date (which specifies the temporal properties of the person in relation with his activity), Place (where the activity was performed), Sex, Type of Activity. Similar elements are defined for Corporate Body and Group.
- The Event is defined as a primary entity that can occur within the lifecycle of an audiovisual or non-audiovisual creation. Examples of Events are Physical Event (e.g. a public screening or a broadcast), Decision Event (e.g. when a manifestation of a creation was evaluated by a censorship body), IPR registration, Award (i.e. the award obtained by an audiovisual creation or an agent), Production event (e.g. dates and places where castings took place, dates and locations of shooting).
- The Collection is defined by a compilation of creations (audiovisual or non-audiovisual).

Relationships are defined between these entities: for example an audio/video creation is linked to persons (actors, movie maker, etc.) and to non audio/video material such as posters, interviewees, newspaper articles. They can also be related to events, such as awards received, public screening.

In order to better illustrate the model, we show how it can be used in practice. Let us suppose we want to model the movie “2001: A Space Odyssey” directed by Stanley Kubrik. We may have a record description of the AVCreation which is as follows:



- Title: “2001: A Space Odyssey”
- Record Source: IMDB
- Identifying Title: “2001: A Space Odyssey”
- Country of Reference: USA
- Production Year: 1968
- Keywords: Science Fiction, HAL, intelligent computer
- Description: “Mankind finds a mysterious, obviously artificial, artifact buried on the moon and, with the intelligent computer HAL, sets off on a quest”



It includes some metadata elements plus a thumbnail describing the AVCreation. We will have several AVManifestations associated to the AVCreation, such as all national versions of the the movie. As an example we show the Italian and the America version, together with two thumbnails.



- Title: "2001: Odissea nello Spazio"
- Record Source: "Cineteca Nazionale"
- Language: IT
- Duration: 141 min



- Title: "2001: A Space Odyssey"
- Record Source: "MGM"
- Language: EN
- Duration: 160 min

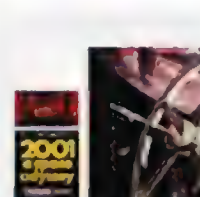
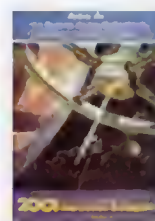
We may have several Agents which have relationships to this movie. As an example, we show two persons, Stanley Kubrick – who was the movie director – and Keir Dullea, who played the role of Dr. Dave Bowman.



- Person
  - Record Source: IMDB
  - Name: Stanley Kubrick
  - Region of Activity: UK
  - Sex: male
  - Type of Activity: director
  - View Biography

We may have NonAVCreations such as Posters, as shown in the next figure, and film reviews.

- Title: Poster
- Record Source: IMDB
- Keywords: Used in Italy
- Date Created: 1968



All these entities are connected through the relationships that exist among them, as illustrated in Figure 2. For example, we may express that the AVCreation “was advertised” through a certain number of posters, and it “was reviewed” in several articles. The movie “was directed” by Stanley Kubrick and it “was played” by Keir Dullea.



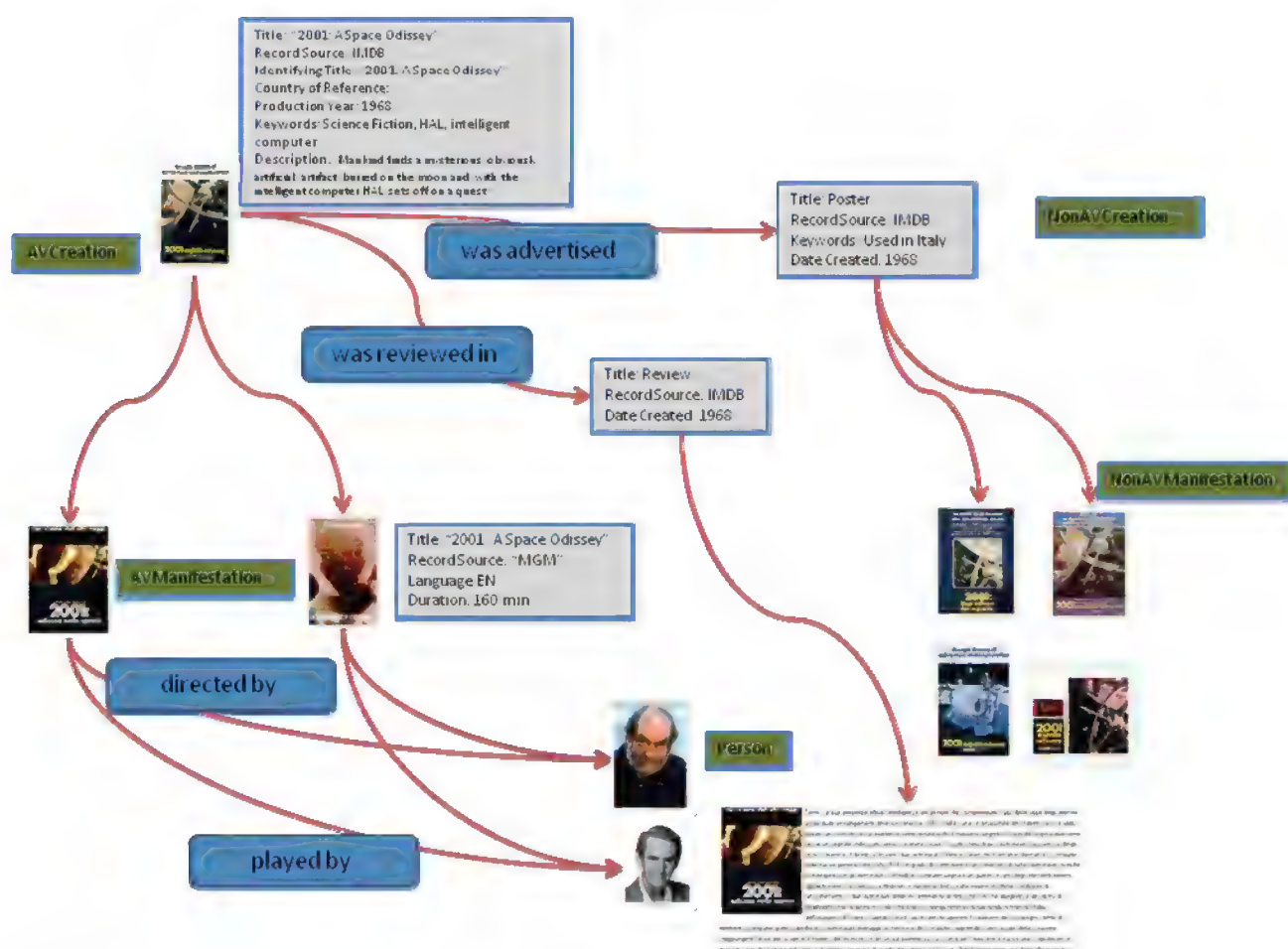


Figure 24 - Example of metadata associated to the movie "2001: A Space Odyssey"

All metadata elements and the relationships can be used to search and browse the archive. For example, it could be possible to search for all movies directed by Kubrick, or for all movies that were reviewed in a given magazine. It could also be possible to browse through the movie directors, movie players. When these movies are displayed, it could be possible to look at all awards received, at biographies of other actors, etc.

#### 4 Conclusion

The *EFG* project has started in September 2008 and will run for three years. Currently the data ingestion has started and a first version of the web portal will be accessible online by end 2010.

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<sup>2</sup> <http://www.europeanfilmgateway.eu>

<sup>3</sup> [http://ec.europa.eu/information\\_society/activities/econtentplus/index\\_en.htm](http://ec.europa.eu/information_society/activities/econtentplus/index_en.htm)

<sup>4</sup> <http://www.europeana.eu>

<sup>5</sup> [http://www.europeanfilmgateway.eu/downloads/D2\\_2\\_Common\\_Interoperability\\_Schema\\_final.pdf](http://www.europeanfilmgateway.eu/downloads/D2_2_Common_Interoperability_Schema_final.pdf)

## GEOGRAPHY OF COSTUME - A HISTORY CASE OF THE ABRUZZO REGION, ITALY

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### Abstract

The paper is devoted to the traditional costume of the Abruzzo Region in Italy in a range of time between 1700 and early 1900; the work has a dual approach, the geographic and the history of costume.

There are many relationships between the traditional costume and various geographical factors. The geography of the costume is a social science because it has as its object of study traditional costumes and aims to find the relationship between the phenomenon of costume, environment, land and culture.

After describing the traditional costume of Abruzzo Region, the relationship between environment and traditional costume was analyzed, how the environment and its elements such as climate, altitude, orography, hydrography, vegetation influenced the process and the various types of costume on one side and on the other side how the production of materials and methodology processes of the traditional costume influenced the environment by modifying the landscape, the farming encouraging or limiting specific cultivations, by setting up industries and by making new road conditions available for transport and communication.

Then we studied the role that the costume played in the society that it has codified. A great part of work devoted to household affairs, mostly carried out by women was aimed to the costume production and so particularly meaningful costumes always accompanied the rites related to the most important life cycle phases. The information obtained has allowed the reconstruction of a social, cultural and economic context.

Finally, with the collected data it has been possible to map GIS devoted to different aspects studied. After integration with charts and tables, the information organized in layers made a detailed regional picture, that can provide new interpretations on the relationship between geography and costume.

The analysis aims to be a methodological reflection produced by the union of geography with history of costume, which are two elements that are woven through the centuries resulting in shapes that reflect cultural, social and economic contexts

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### Costume and geography

Man has always sought appropriate responses to suit the environment in which he lives, the result was a series of life choices that over time have differentiated the various social groups. The clothing is one of the most obvious features that reflect the human attempts to adapt to those needs. The cultural influence in a decisive way has enriched the experience that led to the traditional costume, which is an important aspect of the cultural identity of a people (Bogatirev, 1983).

The scope of this work is to identify and study the many relationships that exist between the traditional costume and various geographical factors. The geography of the costume is part of the social sciences as its object of study is traditional costumes and aims to find the relationship between the phenomenon of costume, environment, land and culture. The geographer does not intervene in the artistic taste of the costume but assists with the method of geography, that is, trying to trace the links between the costume, the space in which it grows and the society behind the coding (Dalla Vedova, 1881). For this purpose, the geographer must know the most important aspects of traditional costume to relate to the territory. The clothing also interests geography because it helps to identify cultural groups not only in the big global breakdown, but also in the study of small communities.

The geography of costume analyses:

*The traditional costume* – First the traditional costume of a country, region or nation is described in its technical and stylistic aspects.

*The spatial distribution* - The "phenomenon costume" examined and georeferenced, will define the distribution and extent, the area of origin, regional distribution, dissemination and processing (Caldo, 1996).

*The ratio of the costume with the environment and geographical factors* - Man has addressed this relationship in different ways over time. And the links which derive from it can be valued by the analysis of the geographical factors which are reflected in costumes. The territory has a number of situations and man has to choose between different possibilities (Febvre, 1980). The geographical factors are those aspects of the area that are most relevant in characterizing the character and individuality, both natural and anthropogenic. The main factors of physical geography, which are climate and environment are analyzed, instead cultural and anthropogenic factors are the human group membership as culture, religion, economic activities, social organization and politics of the group.

*The influences of costume on territory* - The geography of costume aims to identify the influences of fashion on the territory, because it acts on a local and regional level and consequently on the landscape. The shepherds with their flocks, as well as providing a range of food products produced wool, fueling the activities of spinners, the dyers and tailors, as well as that of the small weaving industries. A lot of importance came for the past economy from all these crafts, and from small factories of traditional clothing, some of which have long disappeared. Even today the traditional costume can influence, even if marginally, local economies. In fact, with the renewed interest in archaic working to get a suit, you can recover and return to past traditions of the ancient traditional products that had established a close and respectful relationship with the territory.

### **Geographical factors and traditional costume in Abruzzo Region**

Much of the work has been devoted to examine a case study focused on the Abruzzo Region that has enabled many significant issues.

In the first place geographical factors were taken into account such as physical environment and climate that have provided a complete picture of the region and its resources. It was subsequently analyzed the link between agricultural production, cattle farming and the traditional costume.

Agriculture, which in the past was much more than now influenced by the climate, the type of soil, made possible the development of certain plants. The presence of particular textile plants conditioned the type of tissue of the traditional costume of a region. On the other hand the great demand for textile plants has spread the production of flax, hemp, cotton and mulberry trees for silk. Another important aspect of agriculture for the custom regards the growing or the harvesting of plants with which they dyed dyeing clothes. On the occasions of mourning, the farmers could not always buy new clothes so they used to black-dye the old clothes. With the introduction of chemical dyes, cultivation of these plants has been abandoned (AA.VV. 2008 b).

In Abruzzo and other regions of Italy thistle of wool dealers who worked in factories tissues was used, the thistle pulling the threads made the fabric waterproof. With the introduction of machines which do this task, the cultivation of the card was also abandoned (Manzi, 2007).

Regarding breeding, we found interesting connections between geography and costumes of Abruzzo affecting the production of wool for the preparation of clothing, especially between the seventeenth and eighteenth century, with all the consequences arising from the use of pastures, transhumance, the search for new junctions to select sheep wool (Manzi, 2007).

Regarding industry, the presence of textile industries in Abruzzo for the whole 1800 was very limited, but the statistics show that almost all textile production was practiced with frames in the house. Therefore the processing of the tissue was practiced strictly at home for family needs and the whole cycle of processing fiber into yarn and then woven sector was a significant skill in the context of women's productive activities of each family (ISTAT 1895 e ISTAT 1906).

An economic important aspect were markets and fairs, these were important social events because they were an opportunity for social exchange and economics (Bonanni, 1888). Such situations were of interest to the "phenomenon of costume" as in the markets and fairs where raw materials were bought for weaving, spinning and dyeing fabrics and at the same time products for domestic weaving were sold. On these occasions, women from different towns went to the market and fair with their traditional dress (Torcia, 1986).

After the analysis of physical and geographical factors of production the link between geography and man-made costume, first culture is analyzed. The costume plays a key role in the rites of passage. In any type of society man passes from one age to another and from one social role to another. These steps are accompanied by rituals that ensure control of the society itself (Van Gennep 1981). All these observances provide a particular dress code,



examples are the children's clothing, the difference between the daily clothing and the holiday dress, the dress of the bride and of the grief.

In the past, among human factors, the religious ones have strongly influenced peoples lifestyle, behaviour, eating habits, clothing, religion, determining values for the members of the society. In Abruzzo, where the Christian religion is widespread, some leaders of the costumes were covered with symbolic meanings at the time of prayer as a sign of respect men show their heads, while women have to cover them (Giancristofaro, 1978).

The traditional costume of some Mediterranean countries has been influenced by the religious factor, which requires precepts on clothing during prayer and in daily life. For instance an interesting example is the Albanese costume of a Catholic women and that one of a Muslim women which well represent the difference due to religious factors between two costumes that come from the same country, indeed the structure of the two suits is the same but the Muslim woman's one is characterized by an obvious veil required by the Muslim religion. Another case is the difference between the flamboyant Spanish costumes and the costume of Cadiz which completely hides the female figure and where the Arab influence is evident (Echague, 1963). In the end a case representative for the Jewish religion is the use of some rabbis who button up their coats on the contrary if compared to Western fashion but respect the symbolism of right and left that derives from the Cabala (Dobroszycki, 1987).

Costume represents a link of strong identity and the transmission of culture and this is important for ethnic minorities in many countries (Cerreti, Fusco, 2007). The Abruzzo Region in previous centuries has seen many foreign dominations, and arrivals of slavonic populations across the Mediterranean Sea. Their synthesis are often quite like the costumes of traditional communities and was influenced by elements of different civilizations (Troilo, 1899). The ethnic Albanian minority of Villa Badessa has survived until today and the custom of this country is totally different from that of the rest of the Region but is similar to the clothes in the picture taken in Cruya in Albania.

Another example of trade between populations is the handkerchief used by women of three villages of Abruzzo. The most common type of headgear in Abruzzo is a headscarf, whereas in Scanno, Villalago and Frattura a handkerchief with oriental features like a turban was worn, some experts justify the origin of the turban with the presence of ancient minorities, others argue that the turban goes back to Renaissance models that have been preserved in the isolated valley of Sagittario (Alamagià, 1909).

Thanks to the study of various aspects, i.e. environment factor, production and traditional costume and due to their cartographic representation the research demonstrates that territory and costume influence each other. Data concerning wool cloth industries, agriculture, altimetry and hydrography of the Region has been analyzed (AA.VV. 1929). In three areas the following factors turned out to be important: the presence of water to operate the machines, high altitude slopes that increase the pressure of the water, the presence of grazing for the sheep that provide wool. These are the areas where the industries producing woolen cloth are concentrated, which is still today in Abruzzo a typical handicraft.

### Conclusion

The geography of the costume aims to understand the costume in relation to broader environmental contexts, cultural and historical heritage make it possible, modify it and make it live beyond time.

The methodology produced by the interdisciplinary geography with history of costume, can be applied to study the dynamics that binds the clothing to the territory of the Mediterranean countries. The area of the Mediterranean Sea, on the one hand presents a variety of regional and ethnic histories, on the other hand stands as a cohesive place where different cultures have common roots and codes. The costume reflects the identity of different nations, but inevitably takes into account all the contacts and interactions that occurred in the past centuries.

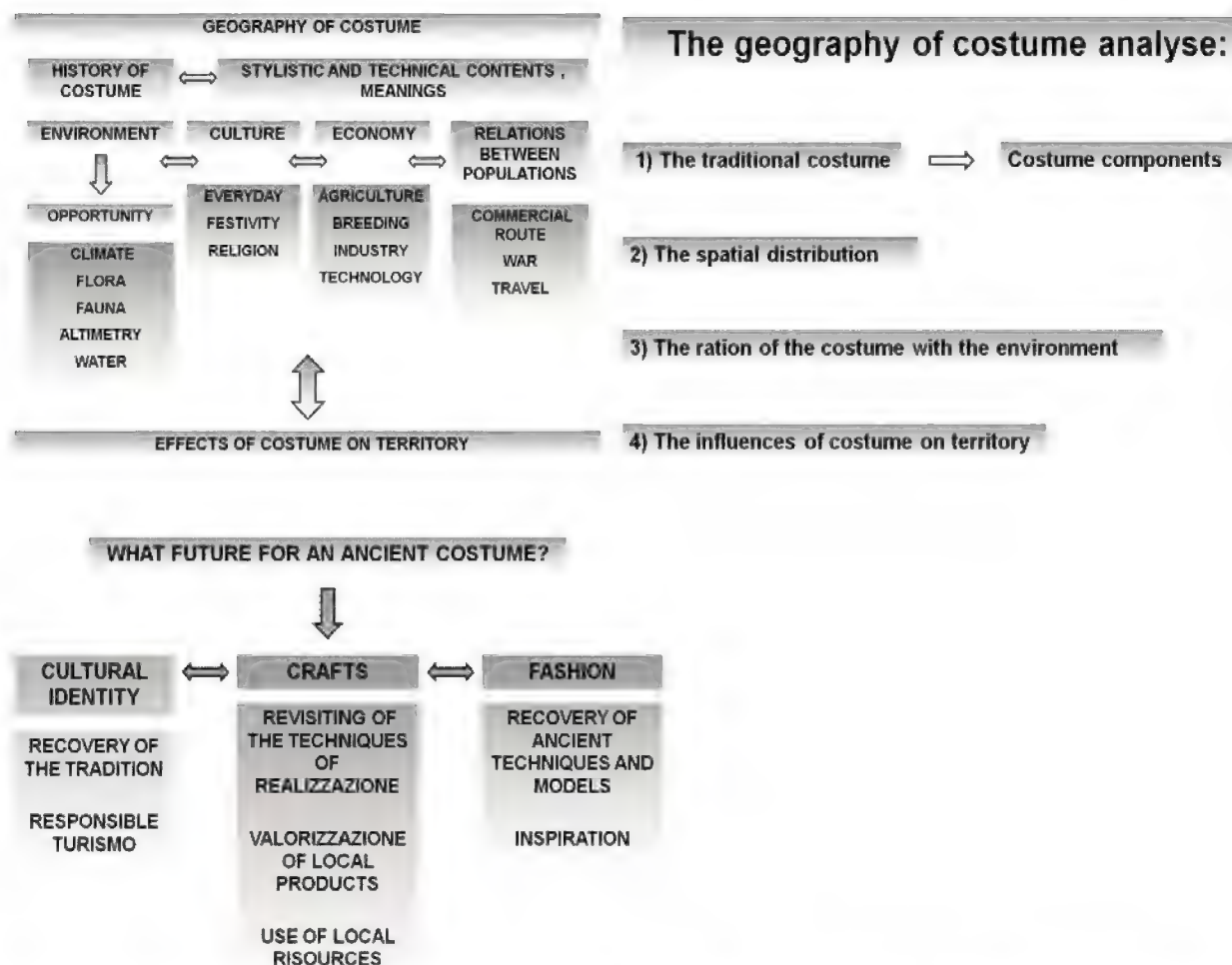
To expose the data collected in different sectors we used GIS to map different aspects studied. The data were organized into levels, whose integration with graphs and tables made it a regional framework that can provide new interpretations on the more interesting relationship between geography and costume.

It is important a good organization of a comparative database which reports the pictures with other information about territory. The phenomenon of Costume has obviously involved the whole Abruzzo and would be ideal to have images covering the entire region. The availability of a significant number of regional data organized in a comparative database allows to relate the "phenomenon costume" with many other territorial information, to determine with certain knowledge whether significant relations do exist and if so to indicate the type and verify the intensity.

The costume is not a given quantity so the findings must be made by analyzing the images. The database could be integrated into a larger project of virtual laboratory, which is primarily the state of information that is possessed at a regional level and then a tool to display the distribution of the most significant elements of costume and to trace the links between clothing and other territorial elements.

The question of cultural identity in particular is the focus of the reflection of various disciplines who are forced to revise the traditional models of study that now seem no longer able to respond to the ever increasing cultural complexity. In this view, the phenomenon becomes an interesting field of investigation, because the main function of costume is precisely to communicate their identity, defining its membership in one or more groups than other, plotting the real and symbolic boundaries between self and other. Therefore studies of costume now involve many disciplines, sociology, history, anthropology, to semiotics, psychology, cultural studies, each of which carries its own specific contribution to understanding the complexity of this phenomenon that involves different social

meanings. Today with the growth of movements, traffic and communication increase we can speak of the Mediterranean as a multiethnic and multicultural society, where conflicts and intolerance are frequently activated and the rediscovery of common values can be an essential element for a new knowledge, for a process of integration and a common development.



Man of Fraine, and woman of Lecce dei Marsi Abruzzo, AA.VV., 1985, XXI-LXI  
Albanian man and woman of Villa Badessa, AA.VV., 1985, XXVI-LXIII

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## THE PEACH IN ITALY: ARCHAEOBOTANICAL, HISTORICAL AND ICONOGRAPHICAL SOURCES FROM ROMAN TO MEDIEVAL AGE

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Introduction and diffusion of the peach tree in Italy is the object of this work. The research was done in cooperation between researchers working on archeobotany and iconography (Palaeobotany group and Applied Botany group of Società Botanica Italiana), and taking part to an international research group (International Work Group for Palaeoethnobotany). The idea of writing a joint paper on a single plant was born inside the European project PaCE (1,2).

*Prunus persica* (L.) Batsch is a rosacean tree originated from western China. Widely cultivated in the Mediterranean basin, it is well known for its tasty and fleshy fruit. The parallel use of historical sources, iconographical portrayals, and archaeobotanical data supplies information on the introduction of peach tree into Italy. The diagnostic features of peach wood and pollen are not sufficient to discriminate the species. Only the resistant stone fruit (woody endocarp) of the fleshy fruits allows the determination to the species level. Columella in *Rei Rusticae Libri* (60-65 AD) and Plinius in *Naturalis Historia* (77-78 AD) mentioned *mala persica*, the last author indicating that this fruit tree was introduced thirty years before the writing of his work, namely between 40 and 50 AD. Plinius reports also the presence of different varieties and the great commercial value of the fruit. In Roman recipes ascribed to Apicius (*De re coquinaria*, liber X), it is reported that peaches were preserved with salt in vinegar and put in glass containers. The oldest artistic representations of peaches are found in wall paintings of the 1st century AD from Herculaneum, and probably also in “festoons” and sculptures of Augustan age from Rome. The oldest available peach finds, dating back to the 1st century AD, come from northern Italy (Modena, 15-40 AD), while the consumption of this fruit was common during the games in the Colosseum (Rome) in the second half of the 4th century AD. In southern Italy, peach stone fruits show a continuous presence between 10-50 AD and the 5th century AD on the paleo-seafloors of the Roman harbour of Naples. Peach endocarps were found in Vesuvian archaeological areas where the species was probably cultivated.

Archaeobotanical finds seem to backdate at least ten years peach tree's presence in northern Italy in respect to historical sources indicating that it was introduced in Italy just before the middle of the 1st century AD.

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(1) “Plants and culture: seeds of the cultural heritage of Europe” PaCE project. (CLT2007/1.2.1/it-182; 15 November 2007-15 July 2009; coordinator A. M. Mercuri) – [www.plants-culture.unimore.it](http://www.plants-culture.unimore.it)

(2) Morel J.-P., A.M. Mercuri (eds), 2009 – Plants and Culture: seeds of the cultural heritage of Europe. Centro Europeo per i Beni Culturali Ravello, Edipuglia Bari.



## GARDEN STONES

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Stone is a highly characteristic material of gardens in every part of the world: unfinished, processed or antique-finished, in the form of various elements, once of local origin and today from all over the planet, not the least as an educational geological outcrop illustrating compositional and morphological characteristics. It is the fundamental element in Japanese stone gardens, where cobbles and gravel are used, with furnishing elements and sculpture in several varieties of rock once of local origin but now extremely varied (as witnessed, for example, by the use today of “Azul Cielo” Argentinean marble gravel to achieve new colour shades). Gardens in cities all over the world see stone play an important role, with vegetation set in paved areas finished with stone materials: an example is the Winter Garden in New York and many hotel interiors. Archaeological gardens are home to archaeological finds in stone of immense value: for example, the green area in front of the Egyptian Museum in Cairo: the garden itself was designed to highlight the archaeological stones. In general, the most prized varieties of marble are used for statuary in gardens in every country: pure white marble was especially chosen by artists famous for statues. Other rocks used in garden sculptures include several varieties of carbonatic and mild siliceous rocks, which are easily worked with a chisel, such as serpentinites and the ophycarbonatic rocks known as “green marbles”. Modern sculptures also see the use of hard siliceous rocks, such as microgabbros known as “Absolute Black Granites” or the gneiss-like metamorphic rocks quarried in the Alps. Stone has always been used for the bases of metal sculptures: in this case, the rock is not only one of the many varieties of “marble” but also includes many varieties of “granite”. The fountains embellishing gardens are often full-scale marble sculptures: marble and several varieties of limestone are the most commonly used rocks. Other furnishing elements in stone in green areas include benches and flower vases, processed from blocks and slabs as well as carved from large erratics, river stones and boulders. A garden almost always contains furnishing stones for the edges of flower beds (binders): these building materials were once only local and reflected the geology of the place. In some cases, historic materials not currently quarried were used, awareness of which is important for restoration. In more recent times, they have been replaced by materials of various origins (for example, tuff from Latium in Merano in place of local “Porphyry” or in the Turin botanical garden in place of “Bargiolina” from Piedmont). Retaining walls have always been installed using squared-off, irregular or river stones. Garden pavings are often in stone: elements include slabs with regular or irregular shapes (mosaics), small cubes, offcuts, gravel and river or sea cobbles. The decoration of gardens often involves unfinished waste stone, that is shapeless blocks of various dimensions. Fragments of waste stone of some size are used as surrounds for flower beds. In arid countries, the flower bed itself may entirely comprise cobbles and waste stone materials. The use of waste in the stone sector is a major problem in the current production world; the garden sector offers the possibility of using considerable quantities of waste rock such as quarry overburden or portions that cannot be used to produce regular blocks, as well as the gravel obtained by crushing waste. Stone for furnishing gardens can be roughed out into elements of various dimensions and even sometimes partially polished to highlight colour and pattern. Stones decorating road roundabouts, for example, involve rocks of various mineralogical composition, first and foremost in terms of colour (reddish for lepidolite, blue for dumortierite, green for mica fuchsite). Stone processed from natural agents such as large boulders, glacial and river masses of large dimensions and cobbles is a common furnishing material in gardens. If such materials are also biodegraded, aesthetic prestige is higher. Cobbles, today also produced artificially (by the mechanical action of drum dressing), may also involve important historic stones (such as the so-called “Misio Marble” granite quarried in Turkey). Outcropping stone itself can be an element in gardens even in naturally modelled forms as a highly characteristic element: examples include surfaces honed by the action of a glacier or the various forms of erosion producing natural sculptures. Deterioration of garden stone is actually a prestige feature. In recent years, garden blocks have also been artificially deteriorated (antique finishing) to resemble the form modelled by natural processes: for example, impure marbles are subject to acid attack to highlight the siliceous parts, which are more resistant than the carbonatic content. The deterioration that is a negative factor for stones used in the cultural heritage in this case is a prestige characteristic of the material. Other forms created naturally by geological processes are used as furnishing elements, such as the lava columns and pillows or geodes. Truncated basalt/andesite columns are often cut and polished at the base. The accumulation of pillows originating from the rapid cooling of lava in the sea are helix-like forms that can be easily separated from each other. Geodes (roundish cavities with walls lined with crystals) and aggregates of large crystals are particularly prized decoration elements. Many gardens combine rocks of various origins, especially following restoration work. Ancient local and imported materials adorn the originally Baroque art garden of Venaria Reale (Piedmont, Italy). Gardens in some cases are an example of appropriate recovery of a stone quarry: gardens in the tuff quarry at Ischia (“La Mortella”) or those set up in the abandoned calcarenite quarries on the island of Favignana (Egadi, Sicily). Abandoned quarries themselves may be naturally transformed into gardens: for example, the stone quarry of Pantelios Castle (Leros, Greece) has become a natural garden. The geology of a place can also be understood through the stones in its gardens: examples are Central Park, Manhattan Island, with outcrops of the Manhattan Formation (gneiss and schists) of the Cambrian Age and Jurassic doleritic seams, while the Obelisk of Cleopatra in

Aswan granite installed in the same park in 1881 shows the deterioration of historic material. In Scotland, slate from historic quarries is widely used near the outcrops to decorate green areas. Unhewn coral limestone adorns the gardens in Cuba near “cayos” where it outcrops. Geology is often the determining element of a garden: for example, the gardens of Castel Trauttmansdorf near Merano are home to the “Geological Mosaic”, a geographical chart in ceramics with blocks and cobbles of the most typical lithotypes (quartz-bearing Bolzano porphyry, Valgardena sandstone, Triassic black volcanite, Schiliar dolomite, principal dolomite, paragneiss, schist, tonalites, densely folded gneiss, phyllites, Lasa marble, granitoid porphyry gneiss, Ivigna granodiorite, quartzite and garnet-bearing amphibolite). Several Alpine lithologies also appear in Japanese garden in the same site, while the hall with “ornamental plants from all over the world” is made up of regular blocks of stone representing the various continents: Red migmatite for Australia, Carrara marble for Europe, opihicalcite for America, "Black granite" for Africa and beige limestone for Asia. The stone of gardens is subject to deterioration: first and foremost, for natural causes (the presence of water is the fundamental element), but also of human origin (frequent vandalism such as graffiti). The stone of fountains suffers accelerated deterioration, as well as the sculptures located underneath trees. The association of different materials creates deterioration: for example, stains on stone caused by metallic percolation. Maintenance of gardens requires the use of new stone. In the event of replacement of rocks, it is important to know something of local geology in order to recuperate, where possible, the same historic materials. Cobbles, however, are increasingly imported: for example, in Great Britain there is widespread use of Indian cobbles, with totally different lithologies to the original materials.

## SESSION D - MUSEUMS AND TOURISM

## **SESSION D1 - MUSEUM PROJECTS, VIRTUAL MUSEUMS**

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### **INDUSTRIAL ARCHAEOLOGY: THE CASE OF FLORISTELLA IN SICILY**

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One of the most important examples in the history of the industry took place in 1780 when a mine of sulphur at Floristella opened in the province of Enna in Sicily. This mine was an estate of Jesuit until 1782 when it was bought by the Barons Pennisi, and the palace was built on a hill in front of the mine, between 1870-1885. The conditions for miners were terrible: initially, the palace must have been used as a fortress against potential attacks from miners arising from the harsh conditions, in which they worked, in fact in the external walls there are many loop-holes for riflemen and in the internal walls there were a lot of secret galleries which led to three underground escape passages. But the Barons Pennisi, found ways of improving the extraction processes. After the economic sulphur crisis, the mine and the Palace passed in to the hands of the Ente Minerario Siciliano in the sixteenth century, a society with the aim of protecting the productive Sicilian areas, however the society failed and collapsed. Between 1986 and 1991, the abandoned palace was sacked. Today, thanks to a project by the Regional Sicilian Assembly, the Parco Minerario has been created in an area of 400 hectares, to give a testimony of the past, by the building of a museum of industrial archaeology, and through the creation of historical and naturalistic tours through the parks. The aim of this work shows that thanks to the study of the material evidence of the industrialization, we can rebuilt some characteristic aspects of a place, of its territory and we can learn about its culture too. These evidences are not only examples of old technologies, but they become material of identification, because they come from a particular period of a society in relation with their productive sectors. This is why this place must be connected with other areas to create a system of museums of industrial archaeology and a creation of means of promotion of these places within tourist system structures.



## MANAGEMENT OF THE ANTHROPOLOGICAL ARCHIVE: THE MUSEUM OF ANTHROPOLOGY AND ETHNOGRAPHY OF THE UNIVERSITY OF TURIN (ITALY)

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### Abstract

For many years, the Museum of Anthropology and Ethnography of the University of Turin has operated a laboratory for the study and conservation of ancient human remains. The work of the laboratory assures the continuity of classical anthropological and paleopathological studies and thus enhances the scientific and historical value of existing or newly acquired biological collections. To improve the study and management of anthropological collections, various lines of research have been undertaken to expand the knowledge of mechanisms of degradation, scientific methods of monitoring the conservation status, and techniques of cleaning and preservation.

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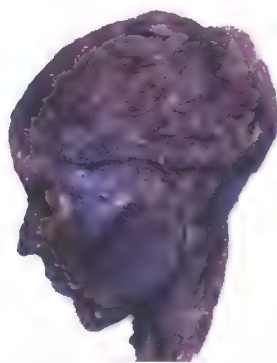
### INTRODUCTION

In recent years, there has been a series of initiatives aimed at increasing the awareness of cultural materials. In particular, aspects related to the anthropological disciplines have aroused great interest, through the revision and renewed examination of large scientific collections. Within this context, the Museum of Anthropology of Turin is a prime example; having long surpassed the role of simple depository of collections, it could be conceived as a dynamic source of information and as a stimulus for research, on account of the special nature of its collections. The creation of the great collections has been an important development for anthropological research. Indeed, the collections are irreplaceable reference systems for the biological reconstruction of past populations. They also assume the important role of true biological archives and, in a global description of man, permit the integration of historical data with those from bioanthropological research.

### THE BIOLOGICAL COLLECTIONS OF THE MUSEUM OF ANTHROPOLOGY AND ETHNOGRAPHY OF THE UNIVERSITY OF TURIN

The Museum of Anthropology and Ethnography of the University of Turin (Italy) was founded in 1926 by Giovanni Marro (1875-1952), medical doctor and anthropologist. The Museum includes anthropological-ethnographic specimens of diverse origin and provenience grouped into primatological, anthropological, palaeo-ethnological, ethnographic and photographic collections. The very rare and sometimes unique specimens represent a cultural and scientific patrimony of inestimable value in terms of both their quality and quantity.

The biological collections include one of the most important Egyptian collections of ancient human remains, consisting of more than 650 complete skeletons and 1300 isolated skulls. To this osseous material are added 80 heads of mummies, 5 virtually complete Predynastic mummies and 15 Dynastic ones (Fig. 1).



**Figure 1** - Mummified head, Dynastic period. Museum of Anthropology and Ethnography of the University of Turin

It is of great interest that different organic materials (bones, teeth, skin, muscles and other tissues, hair, nails) are well preserved. This assemblage was recovered during the archaeological campaign in Egypt (Heliopolis, Asyut, the Valley of the Queens at Thebes, Elephantina) at the beginning of XX century under the direction of E. Schiaparelli, Egyptologist of the Egyptian Museum of Turin, with the collaboration of the professor Marro. Subsequently, he took part in three campaigns, all at Gebelein, directed by Giulio Farina, who succeeded Schiaparelli as Director of the Egyptian Museum. The human remains housed in the Museum come from the necropolis of Assiut and Gebelein. Thus, Marro had the opportunity to put together a very large osteological collection and to create a wide-ranging program of anthropological research. The wide variety of Egyptian remains tells us a lot about different burial conditions, different states of conservation and different taphonomic histories.

The Museum also houses two south American mummies and other ancient osteological collections discovered in the Italian archaeological context, dating from prehistoric to recent times. Other particularly interesting specimens are modern human skulls (complete with mandible) and brains from the dissection room, dating to the beginning of the XX century (Rabino and Boano, 2003).

### **MANAGEMENT OF THE ANTHROPOLOGICAL ARCHIVE**

Recently the Museum established a Laboratory for management of the anthropological archive and a Research Centre for the study and conservation of mummies. The Museum's most important anthropological and ethnological collections are stored in a controlled area without fluctuations in temperature and humidity and with protection from air pollution, according to the guidelines for good museum practices (Fig. 2).

The programme is intended to provide studies in the field of conservation of ancient human remains and discipline-related to define levels of tissue preservation, to prevent decay of organic materials and to improve the knowledge about biological integrity for scientific and display purposes. The activities include the following studies:

- macroscopic analyses of ancient mummified bodies and skeletons in order to evaluate the preservation degree, the morphological changes and the presence of contaminants by natural and ultraviolet light;
- microscopic evaluation of natural processes of decay, artificial processes of preservation and contaminants by histological analyses of soft tissues and hair.
- setting of appropriate conservation and monitoring actions planned for each single case
- ethics of studying and displaying
- inventory.

Museum staff members have just started to rearrange and recatalogue the biological collections and have initiated activities to maintain the biological materials (soft tissues, bones, hairs) in a good state of preservation for future research (Rabino Massa, 2006). Several lines of research have been undertaken to expand our knowledge of the conditions of preservation of the remains; the museum team works to develop low-invasive methods for rapid assessment and monitoring of the tissues. Over the last ten years, the conditions of preservation of the mummies and bones have been checked via histological examinations of tissues, which provide very precise and specific evaluations of degradation from agents such as fungi and bacteria or pollutants (Boano 2006, Boano et al. 2006 a,b, Boano et al. 1999, Fulcheri et al. 1985).



**Figure 2.** Conservation room of the Museum of Anthropology and Ethnography of the University of Turin

## **FINAL CONSIDERATION**

The scientific programme represent a systematic effort to maintain remains according to anthropological up-to-date best practice of preservation. Thinking about the role of mummies and bones as genetic resources, it's important that salvage of ancient specimens should be of high priority for institutions and researchers.

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# INTEGRATED TOOL IN A VIRTUAL MUSEUM OF INDUSTRIAL HISTORICAL HERITAGE

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## Abstract

Integration between different branches of knowledge is key to the treatment and overall understanding of Cultural Heritage. This research has been carried out following this philosophy. It is only in this way that we can consider aspects related to engineering, architecture, history, archaeology or ethnology, which give an overall vision of Industrial Historical Heritage. The aim of this study is to generate a very broad *ad hoc* database which contains information about this heritage, which will be explained from a descriptive and functional viewpoint, in the widest sense of the term. This will provide an attractive and easy to use computer tool which can be integrated into a Virtual Museum platform, in which the database is conditioned by the type of information taken from the Industrial Historical Heritage of the area under study. The results are presented in the context of the cultural heritage of windmills in Andalusia, thanks to the Excellence Research Programme sponsored by the Andalusian Regional Government (Spain).

**Keywords:** Industrial heritage, virtual museum, database, integrated tool, augmented reality.

## 1. RESEARCH AIMS

It is clear that information technology has undergone exponential growth in its development over the last 15 years. This evolution has resolved situations of processing, storage, communication and mobility which allow the user to manipulate and manage working data in practically any location and condition. In addition, this technology creates new techniques and methodologies which mean that the relationship between people and their environment acquires a dimension which would have been difficult to imagine in the recent past.

Taking this technological scene as a basis, our aim is to create a direct application with the purpose of making this technical progress available to cultural heritage, and more specifically industrial historical heritage. The application is centred on the use of the augmented reality technique (AR), integrated into the platform of a virtual museum devoted to the historical heritage of windmills. This initiative has arisen from a Research Project of Excellence of the Department of Innovation, Science and Business of the Andalusian Government entitled "*El patrimonio histórico molinar eólico de Andalucía*" (*Historical heritage of windmills in Andalusia*), directed by Prof. Dr. Rojas Sola.

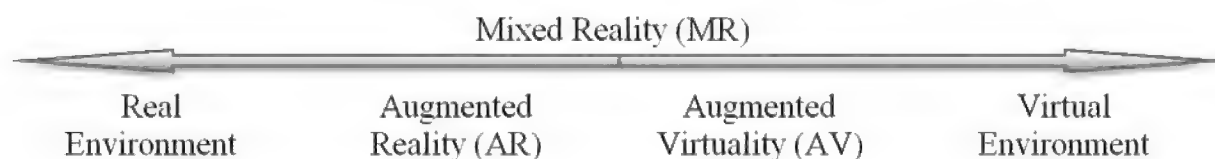
## 2. INTRODUCTION

The concept of reality has been debated throughout history. It was the first Greek philosophers who gave an explanation of reality; Aristotle, for example, considered reality as the information which the senses are able to perceive [1]. However, Plato noted that what the senses observe is only the reflection of true reality, consistent with the universe of ideas [2], although the evolution of this concept continued until Kant stated that reality consisted both of what the senses perceive and the mental categories which are applied to these senses [3].

Today, a widely accepted definition of the term reality covers everything, perceptible or not, which is accessible to science, philosophy or any other system of analysis. Therefore, it can be taken that reality is not unique and can be categorized according to an analytical system.

In this way virtual reality (VR) is considered to be a technological environment whose purpose is to recreate a reality which has previously been generated and defined by computational elements, obtaining a greater degree of realism using peripherals which interact with the user's senses [4].

Once the term reality and its virtual category have been specified, it is feasible to express augmented reality (AR) through a study of the diagram proposed by Milgram and Kishino [5] (*Figure 1*).



**Fig. 1.** Diagram of real and virtual environments and their categorization.



Therefore, AR is considered as the perception of the real environment directly or indirectly, while at the same time including virtual elements as a complement in order to enhance sensorial perception. Augmented reality uses standard techniques and methodologies in many fields, such as industrial archaeology. A good example of the use of this technique applied to the study of heritage is the case of the PRISMA Project [6] which uses 3D techniques applied to cultural and tourism tools, or Ancient Pompeii, which is a project showing the real-time reconstruction of the social activity and environment (with animals and plant life) of the city of Pompeii, using mixed reality techniques [7].

Our research is centered on windmills for milling flour, and studies them from various points of view: historical, archaeological, architectural, and from the perspective of engineering. This last perspective is usually less used, although in the field of engineering it is becoming increasingly common to study and recover the evolution of engineering itself throughout history, from archaeological remains.

The windmills under study are an example of preindustrial historical heritage, and have been an important factor in the socio-economic development of the societies in which they operated, normally with 2 to 4 windmills per population centre.

Given the importance of these windmills, and using AR techniques as a basis, we have conceived a tool which is integrated into a virtual museum (VM), and which is easily accessible to users in an attractive way, through its interaction in the web portal of the VM or with a mobile device, such as a smartphone or Personal Digital Assistants (PDAs) used *in situ*.

### 3. MUSEUMS

Traditionally, On-Site Museums (OSM) have performed three functions: Cataloguing, Conversation and Research of Heritage. However, the concept of a museum has been widened with time, and had incorporated new features, with the emergence of VMs. At first they were simply web pages which showed information and part or all of the catalogue of the OSM, but VMs have evolved into museums designed for educational purposes, information, consultations or encyclopedic activities, among others. In accordance with the development of technology, the concept of the VM has evolved into a wider range of functions [8] [9]:

- Informative: information is presented relating to a general description of the OSM, the opening times and location. These are known as museums with electronic leaflets.
- Virtual Catalogue: both the exhibits on show in the OSM and their environment are digitalized, giving access to all the information on show in a virtual format. This type of museum is known as museums with virtual reconstructions of their environment.
- Learning Platform: educational applications and texts are generated to allow the visitor to interact with the exhibits of the museum, with an educational purpose. These are interactive museums.
- Complementary: all the content of the catalogue of the OSM is digitalized, with the possible inclusion of the museum environment. It is also possible to extend the content with material from other museums, archaeological digs or other sources. These museums are known as large online databases.

The VM is located on the internet, one of the most powerful channels of communication today. In addition, it has been shown that 70% of people who visit the website of an OSM are more willing to visit the museum itself [10], which highlights the fact that the complementary function of a VM can raise interest in discovering the reality shown by the virtual platform. This is the aspect on which the AR tool is centered in this study, as it fulfills the function of a complement to an OSM and is able to transfer the resources of the museum to the object of study, in this case the historical heritage of windmills in Andalusia.

### 4. INTERACTION TECHNIQUES WITH AUGMENTED REALITY

#### 4.1. INTERACTION WITH TANGIBLE INTERFACES BASED ON THE USE OF MARKERS

AR has various interaction techniques between the user and their environment [11]. However, the technique used in this study is the interaction with tangible interfaces using markers to generate AR. It consists of recognition of a marker [12] by an image capture device, such as a webcam or the digital camera integrated into a mobile device. In this way, once the marker has been located and identified, a 3D model or any other multimedia file possibly from the virtual environment is superimposed on the image captured from the real environment. This system implies that the movements made by the marker will be extrapolated to the real element. There are principally two possible forms of the marker: projected onto any part of the material, or even using as marker the object itself [13] or nearby buildings or architectural elements which act as a reference [14].

#### 4.2. MULTIMODAL INTERACTIONS

This type of AR technique consists of using natural input methods such as the voice, a pencil and body movements which are recognized, as they lead to the interaction between reality and the virtual elements.

In order to carry out this function it is necessary to use specially designed peripherals, such as AR Mask or AR Tablet [15], more general devices such as a digital camera, microphones or accelerometers, among others.

#### 4.3. OTHER INTERACTION TECHNIQUES

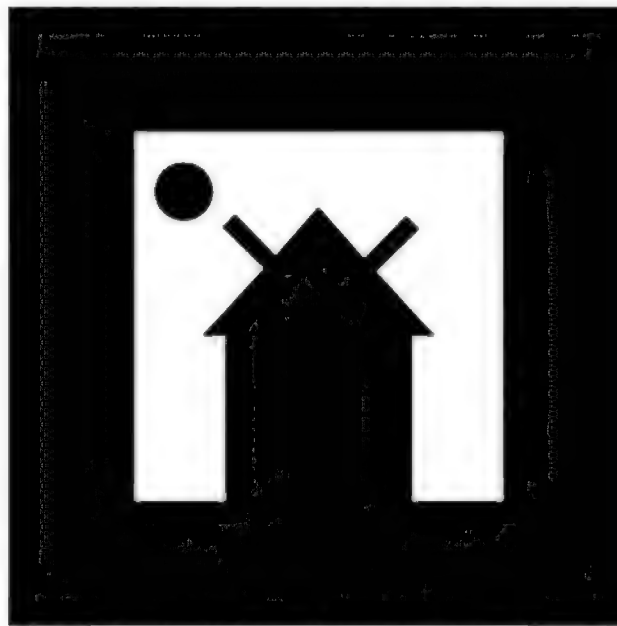
Presently, many applications are being developed which use AR as the basis of their service. An example of one of the most successful is the integration of GPS technology with the camera of the latest generation of mobile phones. It is possible to include elements of the virtual environment in the images captured by the digital camera, based on the coordinates indicated by the GPS [16]. This system is complemented by a sensor which shows direction, in the same way as a compass.

Another form of interaction is by using the AR Pad system [17], which is made up of a joystick, a visual sensor and a marker, in which the virtual model is generated.

### 5. AUGMENTED REALITY APPLIED TO THE HISTORICAL HERITAGE OF WINDMILLS

#### 5.1. MARKER LIBRARY

As has been mentioned above, this research is based on the use of a marker as a link between the virtual environment and the real environment (*Figure 2*). It is recommendable for the marker to possess the appropriate characteristics for it to be identified correctly by the image sensor of this type of element, based on the binary discrimination of color, such as a simple outline, and an avoidance of symmetry in any of its principal axes.



**Fig. 2.** Marker used in the application.

In addition to the recognition algorithm that is used, it should be considered that for adequate processing by mobile devices it is necessary for the image capture sensor to have a resolution of 1.3 to 5 MP. However, when activities are used which imply the need for video streaming configurations, the maximum resolution is 2 MP [18].

In this way, it is possible to generate a series of markers which form the discriminating search keys for the virtual resources associated with flour-making windmills in the databases which have previously been consulted [19].

#### 5.2. FLASH TOOL

It is necessary to highlight in this section the role played by the development of the library which has acted as the basis for the generation of AR applications, called ARToolkit [20], developed by Kato in 1999 under the GNU license. Its development made it possible to generate new libraries for other programming languages. The FLARToolkit, with GNU license, was developed in 2009 by Saqoosha, and uses the programming language ActionScript. Therefore, this allows AR to be integrated into applications which are widely available on the internet, such as Flash applications.

The potential of Flash tools lies in the fact that it has been specially designed to be used on the internet, and in addition can be used in the latest generation of mobile devices, such as smartphones or PDAs, simply by changing some routine characteristics in its compilation stage.

The integration in internet is carried out through a web portal devoted to the historical heritage of Andalusian windmills:

(<http://patrimonioecolico.260mb.com/windmill>), and the most significant hardware requirement is that the computer equipment used has a webcam.

## 6. VIRTUAL RESOURCES

### 6.1. 3D MODELS

Augmented Reality in this research takes as its basis 3D models, with the objective that they should be used as instruments for critical analysis and learning by the VM user. Therefore, the models have been divided into those which show dynamic simulation, and those which contain some type of technical analysis.

The models must work in web environments or in devices with limited processing power, and so it is necessary to use solid formats which exchange 3D information. Various options are available, such as that of the Web3D Consortium, whose aim is to generate a free file format with X3D open standards, and architecture to represent and communicate 3D scenes. The standards which are used for real-time 3D communication are Virtual Reality Modeling Language (VRML) y X3D [21].

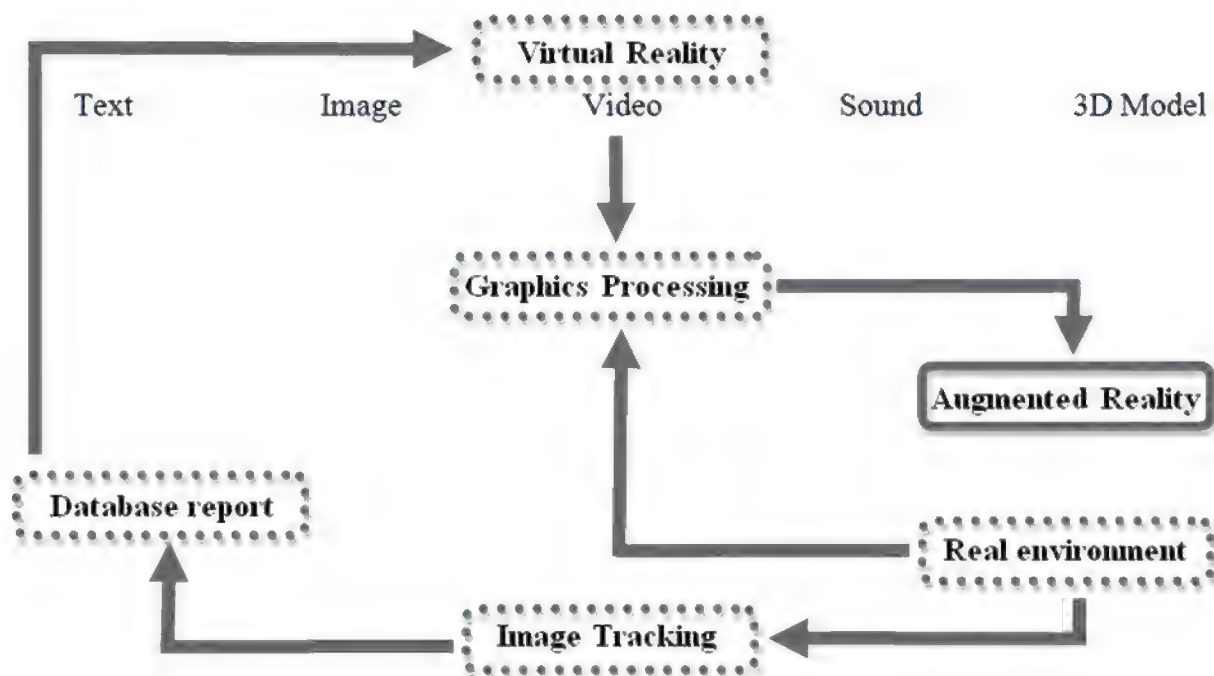
However, the option chosen is the standard COLLABorative Design Activity (COLLADA), which is based on XML diagrams made up of free character standards. One of the advantages of using this standard is that it includes more advanced physics and friction functions than the standards of Web3D can manage, allowing for greater potential of the expected results.

### 6.2 MULTIMEDIA

Another type of virtual resources which AR techniques can include is multimedia information. This can be composed of multiple formats such as text, images, sound and video, although it is video which is most appropriate for inclusion in AR owing to its dynamic nature.

## 7. FUNCTIONAL OUTLINE

Figure 3 shows the functional diagram of the AR tool which has been implemented in a VM web portal, which is formed by a series of inter-connected modules [22]. The starting point is the real working environment, as it is the descriptive leaflet of a windmill taken from a VM, or in the case of a tool for mobile devices, downloaded as a resource of the VM from the information panel of the object. Both realities are scanned to recognize the marker [23], and once identified, the relevant search is made of the database, in order to obtain the appropriate resources for the previously generated virtual environment.



**Fig. 3:** Flow chart of the tool developed for a VM.

At this point, the system will recognize the input of images from the real environment (marker), specifying the place of insertion of the virtual resources and discriminating the information referring to the object studied, as well as the elements of the VR. Therefore, all the information, principally graphic, should be processed using the graphic processing of the application. In this way, the result is the desired AR, in which the real environment is augmented and enhanced.

## 8. RESULTS

The development of this research has generated an application based on Flash tool, and on the technique of interaction using a marker to implement AR. Each marker has been made to correspond to a different virtual resource, so that the application is equally suited to use as a resource on the web platform of a VM (Figure 4), or can be downloaded to a latest generation mobile device, to interact *in situ* with the information provided by the VM (Figure 5).



**Fig. 4.** AR tool user interacting with the information leaflet obtained in the web platform of the VM.



**Fig. 5.** Image of the functional diagram of the informational panel, the marker and the 'San Francisco' windmill (Véjer de la Frontera, Cádiz, Spain).

With the use of the latest generation of mobile devices, the interaction is carried out using the digital camera incorporated into the device, which reads the marker located on the information panels situated around the



windmill (*Figure 6*). In this way, the tourist's experience of the historical heritage is enhanced through 3D models, both in the functioning of the windmill itself and in details of certain elements. Previously the application is downloaded in the mobile device from the VM, which allows for personalized guided visits [24].



**Fig. 6.** Remains of the 'De la Horca' windmill (Puebla de Guzmán, Huelva, Spain), with the current information panel.

## 9. CONCLUSIONS

This research has generated an application with a high value applied to industrial heritage, owing to its ease of use, interactivity, and the quality of the resulting information. In addition, it can be used *in situ* as part of a visit, enhanced by the AR resources contained in the VM which is linked to the historical heritage of windmills, and this allows for guided tours according to the personal criteria of the user.

Another interesting aspect is the fact the VM user does not play a passive role when using the AR tool or when or when visiting the archaeological remains, but rather should interact with the AR tool and the site visited in order to gain access to information which would normally not be available to a non-expert. This interaction is natural, as the user is in total control.

In terms of the Flash application located on the web portal, it should be noted that the bandwidth will limit the level of detail (LOD) shown by the 3D model. However, it is possible to show an explanatory video instead of the model, in cases where greater image quality is needed, or because of technical needs.

## 10. FUNDING

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## **EUPHORIC BEGINNINGS - DYSPHORIC PRESENT: THE ANTHROPOLOGICAL COLLECTION AT THE NATURAL HISTORY MUSEUM VIENNA IN THE FIELD OF CONTROVERSY BETWEEN SCIENCE AND ETHICS**

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The process of successful implementation of Anthropology dates back to the middle of the 19<sup>th</sup> century when anatomists became increasingly interested in the variability and origin of human beings. This development was influenced by contemporary social, political, humanitarian- and cultural-scientific frameworks accompanied by the establishment of methodical innovations (e.g., of the exact measuring technology) and the setting of human skeletal collections for demonstrative and comparative purposes.

The human relics were frequently acquired in the context of colonial or other explorative attempts by officials or private collectors, often encouraged by curators and were delivered to the most important centres of European research (see e.g., the NOVARA sailing trip around the world). Today, at the Natural History Museum Vienna we see ourselves confronted with a more than 130-year-old heritage, a lieu de mémoire that encloses about 40,000 objects which raise a plethora of questions regarding historical acquisition politics and – due to the special position of the field within the biological disciplines – to an adequate handling of these specimens. Concerning the use of this mass of sources not only the perceptions of social-scientists, but also of natural-scientists (which necessarily require such collections for evolutionary studies) collide – a discourse, which became aggravated just recently when dealing with repatriation of Australian indigenous remains and which underpins the urgency of evaluating the museal weak spots of the past in view of provenance, acquisition circumstances, object- and reception-history.

Because the continuously grown collection of human relics also reflect in linear sequence the personal interests of the curators as well as the institutional programmes and requirements (often war has been seen as “ideal occasion” for collecting anthropometric data or objects), the prerequisites for compiling a critical compendium of the Austrian anthropological- ethnographical history of science are given in replenishing the above mentioned desiderata.

Aim of our project (funded by the Austrian Ministry of Science, and in co-operation with the Federal Pathologic Anatomical Museum Vienna, the Institute of Anatomy, Medical University of Vienna, the Department of Anthropology, University of Vienna, and the Museum of Ethnology) is the reconstruction of the provenience and acquisition circumstances as well as the documentation of a selected sample of osteological items stored at our Department of Anthropology, which were collected between 1850 and 1950 in the course of voyages of exploration and expeditions. Additionally, we intend to carry out inquiries regarding the biographies of the collectors (e.g., Weisbach, Brenner-Felsach, Kirchner, v. Luschan, etc.) and to incorporate these findings within the historical and contemporary context of knowledge. Finally, we have not only to reflect and discuss ethical concerns and the consequences for today's practises that are oriented towards political correctness in dealing with this legacy, but also to improve the scientific practise by including the view of the peoples once investigated by European protagonists.



# A VIRTUAL HISTORY OF ARCHAEOLOGICAL COMPUTING

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## 1. Introduction

The international Journal «Archeologia e Calcolatori» [1], published by the Istituto di Studi sulle Civiltà Italiane del Mediterraneo Antico of the Italian National Research Council - Cultural Heritage Department, celebrates its 20<sup>th</sup> anniversary this year (Fig. 1). Established in 1989 by Mauro Cristofani and Riccardo Francovich [2], during these years «Archeologia e Calcolatori» has played a catalyzing role in the international panorama as an observatory of the main theoretical and methodological aspects of information technology applied to archaeology.

Several stages of the life of the Journal have contributed to its international development and have allowed expert readers to appreciate the ongoing evolution of the archaeologist's approach to the generation and spreading of digital information. In particular, this has been achieved through the periodical publication of special thematic issues dedicated to recent and debated subjects: *Choice, Representation and Structuring of Archaeological Information* (in 1994), *Methodological Trends and Future Perspectives in the Application of GIS in Archaeology* (in 1998), *New Frontiers of Archaeological Research. Languages, Communication, Information Technology* (in 2004); *Virtual Museums and Archaeology* (in 2007).

Many international institutions involved in computing archaeology have asked to have their Conference proceedings published in the Journal, for example the European University Centre for Cultural Heritage in Ravello; the Association Internationale Archéologie et Informatique; the Universities of Rome La Sapienza, Florence and Naples; the Commission IV of the Union Internationale des Sciences Préhistoriques et Protohistoriques; the Université de Paris 1 Panthéon-Sorbonne. Other Proceedings are now in press, thus consolidating this editorial tradition.

Moreover, between 2004 and 2008, the «Archaeological Computing Newsletter», established in 1985, was published as a six-monthly Supplement to «Archeologia e Calcolatori» [3], until we have begun to issue in 2007 a new series of Supplements which represent an important addition to the regular annual publication.

## 2. Innovative scientific initiatives

As Editor of the Journal and as a participant in this important Congress, which sees us gathered here in Egypt, in the city of Cairo, rather than present a more detailed assessment of this long editorial activity, to which many pages have already been dedicated [4], I would like to illustrate some recent initiatives strictly connected to the history of the Journal and the discipline it represents: Archaeological Computing, which is based on the dialogue between ancient past and modern technologies.

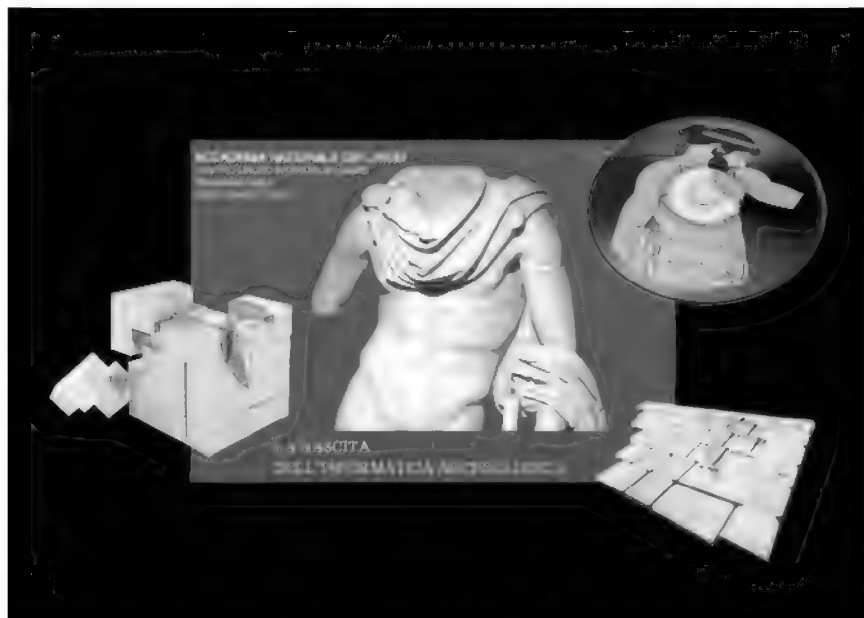
I refer in particular to two important scientific events: an international Symposium dedicated to «The Birth of Archaeological Computing», held in Rome at the Accademia Nazionale dei Lincei, in October of 2008, the Proceedings of which are now in press in the 20<sup>th</sup> issue of the Journal [5], and a joint initiative to build a «Virtual Museum of Archaeological Computing», which is being created thanks to the collaboration of many members of the Scientific Committee of the Journal itself.



**Fig. 1** - Home page of the website of «Archeologia e Calcolatori» (<http://soi.cnr.it/archcalc/>).

## 2.1 The Birth of Archaeological Computing

The idea of the Symposium arose from the necessity of reflecting on the history of archaeological computing, going back to the stage of the pioneers' applications, and reassess its theoretical basis, which has been suffocated by the exponential growth of technology since the 1990s. The Symposium (Fig. 2) was organised by the Centro Linceo Interdisciplinare "Beniamino Segre" [6], which for many years has been involved in the advancement of research in the field of Humanities Computing, together with the Italian CNR and in collaboration with the Ministero per i Beni e le Attività Culturali, the Ministero dell'Istruzione, dell'Università e della Ricerca and the Università Italo Francese.



**Fig. 2** – Presentation of the Symposium on The Birth of Archaeological Computing.

During the Symposium, three generations of scholars from different countries described their own experiences in different periods of time (from the 1970s onwards) and sectors of application, stressing common criticism, recurrent difficulties, results and achievements for archaeology and IT on the whole. The main issues which were dealt with can be summarised as follows:

- Archaeology and non-archaeology facing IT
- The golden years for mathematics and computers in archaeology
- Experiencing ancient landscape: digital cartography and GIS
- The automatic processing of documentary research
- From anarchy to good practice: the evolution of standards
- From apparatus of scholarship to web resources
- Knowledge representation and data dissemination
- Computational intelligence in archaeology

As part of the workshop section of the Symposium, the prototype of a “Virtual Museum of Archaeological Computing” was also presented. This project is being carried out with the purpose to reconstruct the history of an “interdisciplinary discipline” which set its roots in the 1960s. This initiative, therefore, is not aimed – as many archaeological virtual museums are – at reconstructing, through a process of recontextualisation, the history of a work of art, a monumental complex, an ancient landscape or town, a collection of objects, but that of a boundary discipline [7].

## 2.2 The Virtual Museum of Archaeological Computing

The architectural plan of the Virtual Museum is built around three different exhibition rooms, dedicated respectively to the Protagonists, the Methodologies and the Technologies, in order to offer an overview of the history of research, the technological tools and the archaeological applications, recontextualising them within the main archaeological research sectors involved in the process of data digitisation.

The prototype shows an example of how information about single scholars will be presented in the first room. The life and work of five scholars, who operated in the field of computer applications in archaeology starting in the 1960s, have been analysed. The academic careers of these scholars, in fact, started when computers began to move from the Sciences into the Humanities. A biography, a bibliography and a virtual interview help visitors understand

their experiences from a chronological, methodological and technological point of view and retrace the research paths that they followed (Fig. 3). The narration of the protagonists will also enable visitors to better understand how technology has influenced their theoretical and methodological choices and highlight the consistency of intent which has characterised the research activity of these pioneers.

As in the Sixties the use of computers was specifically addressed to the electronic calculus, statistics and mathematical methods have proved to be the most successful types of analysis of archaeological artefacts: research work carried out by Amilcare Bietti, George Cowgill and Jim Doran are still masterpieces in the history of archaeological computing, notwithstanding the subsequent technological developments. A special case is represented by the work by Jean-Claude Gardin, who, since the 1950s, with his spiral method and the bridge between observation and hypotheses, laid the foundations for a theory of archaeological knowledge representation that is still as feasible as the most modern solutions offered by the Semantic Web.

The second room is dedicated to the Methodologies: the prototype shows six diverse subjects, also edited by experts – all members of the Editorial staff of «Archeologia e Calcolatori» – which have offered important results in archaeological research (Fig. 4). These include inventory systems, databases, GIS and digital cartography, multimedia systems, Internet applications and Museum documentation systems; the subjects selected are therefore joined in a single environment and substantiated by applications developed from the 1980s onwards.



**Fig. 3** - The page dedicated to Jean-Claude Gardin in the section of the Protagonists.



**Fig. 4** - The first page of the six multimedia presentations dedicated to the Methodologies.

These applications are recontextualised within the main archaeological research sectors involved in the process of data digitisation: Cultural Resource Management, classification of archaeological finds, surveys and excavations, data diffusion and education. They also open more complex theoretical perspectives suggested by the use of computers: data encoding and formalisation; evolution of languages, standards and metadata; the geographical dimension of knowledge; from reality to virtuality; communicating archaeology through the web.

The installation of the third room, dedicated to the Technologies, will involve the contribution of engineers and computer specialists, with the aim of reconstructing the evolution of hardware and software tools from the Sixties until today. In this case, rather than just visiting a room of a “Museum of Archaeological Computing”, it will be possible to navigate within a “Museum of the Archaeology of Computing”. During the Symposium, particularly moving was Edoardo Vesentini’s account, who went back to the years in which Enrico Fermi promoted the construction of the first electronic calculator in Pisa. A model of reference should also be the experience of the Virtual Museum of Italian Computer Science History, developed in the 1990s and presented by Paolo Paolini.

The general aim of the Museum is to reconstruct the history of archaeological computing, through four chronological periods, acutely described by Tito Orlandi: the age of the precursors (until 1960); the age of the pioneer applications (between 1960 and 1970); the age of the experiments and research projects (between 1970 and 1990); and, the age of the triumph of technology (from 1990 to nowadays). The website has not yet been published on the Internet, as it is difficult to render in complete form the history of a discipline that we are reconstructing year by year, proceeding with our enquiry step by step. In any case, some excerpts will be illustrated in the website of «Archeologia e Calcolatori», in the occasion of the publication of the 20<sup>th</sup> issue.

### 3. «Archeologia e Calcolatori» and the Open Archives Initiative

The “virtual experience” that we are carrying on is, in any case, stimulated by the planning of new education and communication strategies, and is already improving our skills in the field of knowledge enhancement and sharing. Using the web as a scientific transmission tool is an experiment that we have already tested as part of the editorial policy of «Archeologia e Calcolatori». In fact, to increase the visibility and diffusion of the Journal data archive, a project for digitisation and web diffusion of its content was started in 2004 and an OAI-PMH (Open Archives Initiative-Protocol for Metadata Harvesting) repository of published articles has been implemented [8]. At the same time, a new version of the Journal website has been developed and to the traditional paper publication we have now added a digital platform. In this way, we intend to carry on with the original purpose of «Archeologia e Calcolatori»: to acquire sources of information, but also to provide them.

The result is that «Archeologia e Calcolatori» is now an OAI data provider. Among the articles published in the twenty-year editorial activity, at present more than 200 articles can be freely downloaded in .pdf format from the Journal website. The system has proved to be completely satisfactory for this task and we are now increasing our circulation activity by implementing the CNR database SOLAR (Scientific Open-access Literature Archive and Repository) and setting up a co-operation program with the CulturaItalia Portal for the harvesting of our metadata, thus giving the Journal the possibility to make their resources available to web users at large.

«Archeologia e Calcolatori», which has been firmly anchored during these past twenty years to some basic principles – such as the use of multilingualism, the dialectical relationship between theory and experimentation, the continuous bibliographical updating – intends in this way to add a direct experimental involvement in the choice of ICT solutions for the online dissemination of scientific contents to its institutional role as an international reference point for archaeological computing.

In conclusion, I would like to take this opportunity to acknowledge the support of the Italian CNR, without which «Archeologia e Calcolatori» would never have existed. A special thanks to the National Scientific Consulting Committees, the Cultural Heritage Special Project and the Cultural Heritage Department.

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## CONFIDENTIAL FACILITY REPORT (CFR): A TOOL FOR QUALITY EVALUATION AND DECISION SUPPORT IN MUSEUMS

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### Abstract:

In Italy there is currently an ongoing process for analysing the quality of museums. Following the Strategic Act established in 2001 on the scientific and technical criteria and the standards of operation and development of museums, (“Atto di indirizzo sui criteri tecnico scientifici e sugli standard di funzionamento e sviluppo dei musei, D.M. 10/5/2001”), the Regional Administrations are improving the standards on various aspects of the museum context (structures, safety, security, management and care of the collections, ...). They are also defining the right tools for identifying any missing aspects which require urgent action and how best to use and direct investments within the museums.

In this context the proposal, of a detailed report aimed at outlining the situation in each single museum, is presented. The objective is to collect information as a starting point both for a shared and participated analysis of the risks related to conservation and for beginning a decision process aimed at improving the quality of the museums’ structures and their services. This report will make it possible to highlight the needs related to preventive conservation and the safeguarding of the collections and, above all, it will enable to define correct management procedures for the creation of a “system of quality assurance”, based on the potential of the museums’ organizational structure and the awareness of what must be done to regulate, standardize, improve and renovate existing structures.

The Authors present the tool called Confidential Facility Report (CFR), which was developed in Piemonte region (Italy) during a research project financed by “Fondazione per l’Arte” of the Compagnia di San Paolo (2007-2009). CFR is mostly graphic and photographic, but not only; it is divided in sections dealing with different aspects: facilities, layout, installations, exhibition, conservation of the collections, management, safety and security, maintenance. The current situation of every section is analysed and commented upon and any faults regarding the above mentioned aspects are highlighted. The CFR can be adapted, where necessary, to various kinds of cultural heritage (museums, monumental sites, historical buildings, church ...) and is also useful for collecting information for the standards related to museum accreditation program developed by regional administrations.



Fig.1 : to give an example of report about collection care - preventive conservation.

The analysis process about the quality of museums is currently ongoing in Italy. Starting from the Strategic Act for techno-scientific criteria and standards for museum management and development (DM 10/5/2001), Regions are developing standards concerning different aspects of museums, as well as the structures, the safety, the care and the management of collections. In the meantime they are also developing evaluation processes to highlight lacks which require urgent actions and how best to use and to direct investments within the museum.

The main aspects of the Strategic Act concern with the decision on focusing first on museums to define criteria and standards and then extend the process on other cultural heritages. They are relevant for improving museum ordinary management and enhancement, flexible to museum typologies and characterized by a multidisciplinary approach.

There's a subdivision in 8 Functional Areas, and each one contains a Premise, a Technical Standard and a Guidelines document issued by a workgroup. The 8 Functional Areas are: I –Legal status; II-Resources; III-Facilities, IV-Personnel; V-Security; VI-Collection management; VII-Relations with visitors; VIII-Relations with the territory.

The standards have different meanings in the Areas, as an unambiguous requirement (threshold levels and standards, for examples for collection care, security and risk prevention), as quality rating or as guidelines.

Italian Regions are free to develop and apply their own standards, achieving different schemes of application on various aspects of the museum context in order to follow the Areas of the Strategic Act, but they have different timing in the application; some are at an advanced level, some are experimenting the process and some have not yet begun any process.

Among the principles of the Strategic Act, it is remarkable how “the museum’s quality has not to be evaluated in relation to its owned collections, its public attraction, its physical dimension or even to an analysis of technical evaluation on structures and plants, but to the ability of achieving its own mission. Museums are requested to operate on “quality guarantee” as well as providing series of planned and efficient actions necessary to give adequate confidence in maintaining certain “quality standards”. Thus museums have to fulfil a “quality scheme”, that are namely the organisational structure, the procedures and specific resources for quality lasting performance”.

The development of Accreditation Procedures, carried on by the Regions, follows the previous aspects, in order to evaluate the quality of the service given by museums, in all the areas of museum activities.

The standards of the Strategy Act, as already said, have been elaborated differently from the Regions. And we can discern different cases and opposite situations. In Lombardia and Emilia Romagna, for instance, the accreditation is possible to those museums that have minimum compulsory requirements regarding services (at least for the process to be started); on the other hand, in Piemonte Region it is possible to evaluate the services given by the use of interconnected and graded parameters, with growing levels of complexity.

[illegible]

**Figure n. 2.** example of self-evaluation file used in Regione Piemonte, regarding the areas of the exhibition

On the other hand the standards, if a more detailed and complex approach is needed, are not enough and they may be used together with other tools mostly concerning more than an issue at once. In Italy, at the moment, it emerges as necessary, for the museums' quality evaluation, the development of methodologies and procedures that can support the management for future actions and activities.

In particular the authors refer the experience of Piemonte Region, which is active in “promoting protection and development of activities related to Cultural Heritage” (L.R. 58/78) and the regional priority involves projects of renovation of cultural heritage, reuse and management, both included in the future regional policies and in progress. Referred to these priorities Piemonte Region intends:

- spreading application and introduce museum standards through the creation of an accreditation programme,
- defining the right tools for identifying any missing aspect which require urgent actions,
- creating a protocol to evaluate how best direct investments and if the requests of financing made by museum institutions and monument sites are appropriate.

### The Confidential Facility Report

In this context, it was carried out the proposal of a detailed report aimed at outlining the situation in each single museum. The authors during the Cairo Congress have presented the Confidential Facility Report (CFR), which was developed in Regione Piemonte during a research project called “Security of Cultural Heritage”, co-financed by SiTI (Istituto per i Sistemi Territoriali per l’Innovazione), (2007 - july 2009, Torino). The project concerned with safety, security and conservation topics, with the study of the possible introduction of new technologies in museums and with an analysis of the technological and organizational needs of the end users.

Confidential Facility Report (CFR) provides an overview, aimed at outlining the situation of the museum, and collecting information as a starting point for quality evaluation of facilities, security and collection management in museums and cultural heritage.

CFR is mostly graphic and photographic, but not only; it is divided into sections dealing with different aspects: facilities, layout, installations, exhibitions, conservation of the collections, management, safety and security, maintenance. The current situation of every section is analysed and commented upon and any faults regarding the above mentioned aspects are highlighted.

The name derives from the fact that the report contains confidential information, for example information regarding security aspects; for this reason it is given directly to the Director of the museum.

The objective is:

- to collect information as a starting point both for a shared and participated analysis of the risks related to conservation and for beginning a decision process aimed at improving the quality of the museums’ structures and their services.
- to highlight any problem issues towards which to direct the resources can be faced so as to improve the quality of both facilities, security and collection management.
- to highlight the priority for actions as a support in decision making.

This report will make it possible to highlight the needs related to preventive conservation and the safeguarding of the collections and, above all, it will enable us to define correct management procedures for the creation of a “system of quality assurance”, based on the potential of the museums’ organizational structure and the awareness of what must be done to regulate, standardize, improve and renovate existing structures and their service.

The faults are not highlighted simply because they need to be corrected but they relate to a priority report, based on the real needs of the museum, which can be also accompanied by indications on how to set up experimental areas.

The CFR can also be useful:

- for writing guidelines for the design of new museums or for any restoration, renovation and refurbishment purposes occurring as part of an enhancement strategy of Cultural Heritage,
- to collect information for the compilation of a Facility Report in case of artwork loans,
- to support the process of accreditation programme for museum standards

### The procedure of CFR

The documents, which define every phase of the process are:

- |      |   |  |
|------|---|--|
| DD   | Data Document (check list filled by the surveyor to individuate equipments and performances)                            |  |
| CFR  | Confidential Facility Report (delivered to the Director)  |  |
| Ex S | Executive Summary (to highlight priority of action and suggestions)   |  |
| FR   | Facility Report (for artworks lending procedures, from the info of DD)  |  |
| RR   | Registration Report (check list for the accreditation following regional museum standard; starting from the info of DD) |  |



**Figure 3:** Documents defining the phase of the CFR

The collection of information and the highlighting of faults are carried out both through survey activities with the DD and through workshops at the museum.



The **Data Document** is the means for collecting information, formed by a large number of check lists, divided according to the areas of CFR (listed on the following pages), with the aim to highlight the performance and the facilities of the museum being analysed.

The workshops aim is to analyse needs, to share technical information, to discuss problems that are typical of the institution and to discuss the best way to organize the management of the structure, security, and conservation. Before the workshop, the survey activities have to be done. During the workshop the objective is to activate a dialogue and discussion with the different professionals from both inside and outside the museum: the director, the curators, the security manager, the designers (if present), the person in charge of outsourcing companies (services of packaging and transport of artworks, construction of storage containers and exhibition showcases, 24 hour surveillance, maintenance etc.) and a coordinator involved in the CFR project.

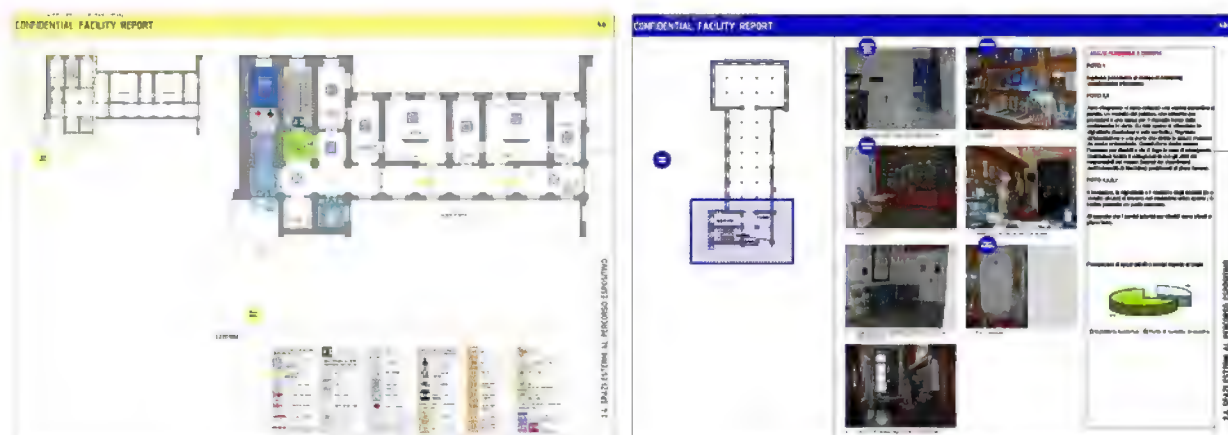
The **Confidential Facility Report** is the main document, is compiled using data from the DD and the workshops; the data is provided in several files, that highlight:

- a general museum analysis, through the use of plans, symbols and pictures,
- a functional analysis,
- a critical analysis of the weak points revealed in different areas.

One part of each section is dedicated to the contents of the museum, after which the aim is to highlight the operation and management of these contents together with any faults, which may be present and improvements, which may be necessary. This can be done both by tools of management planning and through experimental activities.

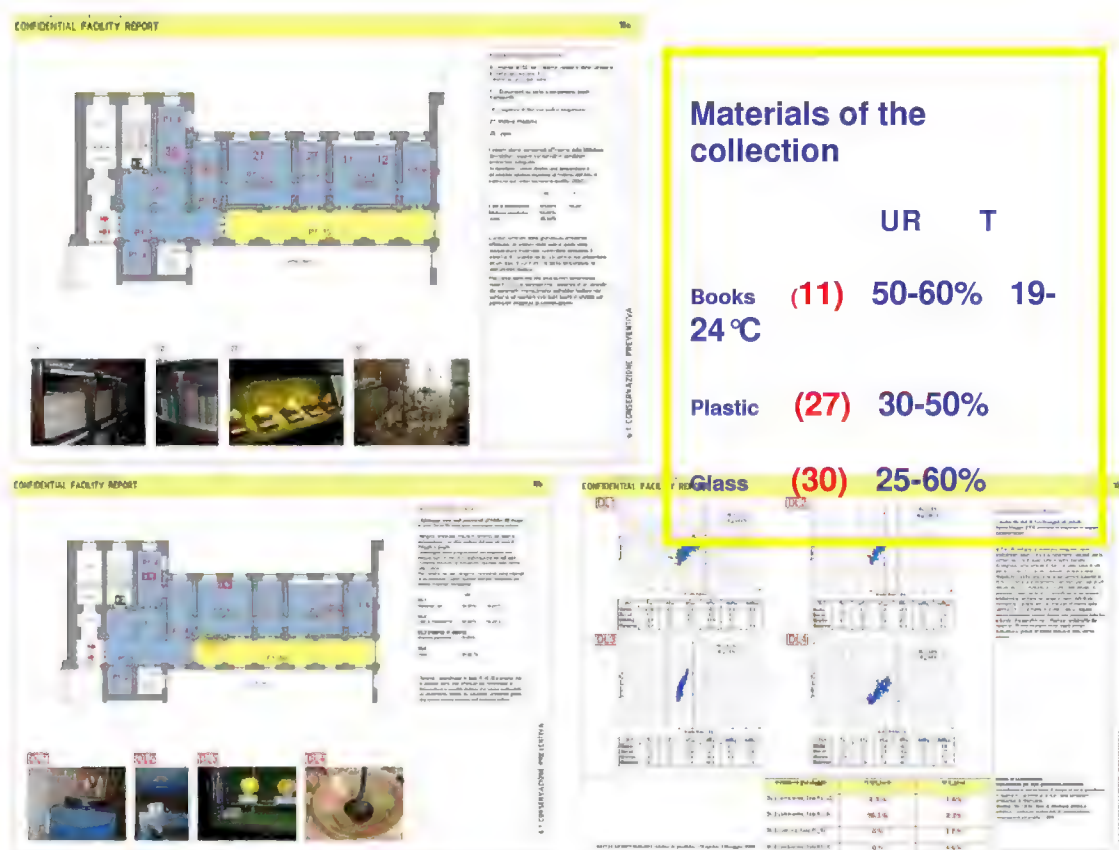
The areas of investigation in which is divided are the Part A, more dedicated to architectural aspects and Part B, dedicated mainly to management aspects. The Part A concerns with General information, Facilities, spaces and distribution analysis, Installations, Exhibit's analysis. The Part B concerns with Administrations, Collections Management, Safety Management, Maintenance.

The CFR also contains an **Executive Summary** which highlights a synthesis of the faults and the relevant aspects. This is no longer divided according to the previous areas of investigation, but contains a combination of the points and a complex elaboration of the data that has been collected in order to create a list of priority that can be adapted to the real needs of the institution.



**Figura 4:** examples of files – areas outside and inside the exhibition path





**Figure 5:** examples of files – Collection management – preventive conservation

Using the information collected from the DD and elaborated in the CFR, it is also possible to compile a **Facility Report (FR)** with which the museum can borrow artworks. We studied various Facility Reports, in particular those used in american and english museums, which are recognized on an international scale.

Another use we suggest is that of the **Registration Report (RR)**. The information in this report can be used to compile the self-assessment forms relating to the structures, safety, security and collection care. These are necessary for reaching the standards of quality defined by each regional administration.

#### Opportunities for implementation:

The CFR, during the experimentation, has met with positive feedback, especially because the documents, analysing the contents of the museums are often accompanied by graphs and tables that are easy to read for anybody. We believe that some improvements could be done starting for examples by digitalization of the tool and creation of a data-base, in order to have an easier access to the data.

Generally speaking when a museum decides to undergo a process of extension, reuse, or renovation, for examples regarding the internal areas, exhibitions or installations, and above all without incurring undue and excessive expenditure, the CFR can be used to facilitate decision-making following a list of priorities.

Another aspect which has recently grown in importance is that of how to save energy within the building. In this case it can be used as a Road Map to a “green” museum. This analysis has yet to be perfected due to the difficulties on gathering specific data.

It’s also possible extend its application to the various kinds of cultural heritage, such as monumental sites, historical buildings and churches, archaeological sites, but also to buildings that have no connection with cultural heritage, like hospitals, offices and banks.

# OMERO: MULTIMODAL EXPLORATION OF VIRTUAL REALITY OBJECTS

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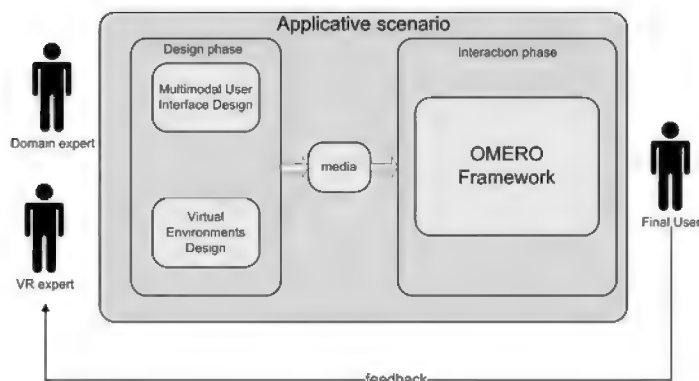
## Introduction

The increasing computing power and storage capacities of standard PCs and the growing use of Internet to share contents in form of 2D or 3D environments, allowed to virtually reconstruct and explore Cultural Heritage (C.H.) for many application goals. Technologies such as VRML or X3D allows web virtual navigation of 3D models of statues and architectural\archeological sites overcoming space, safety, delicacy barriers.

Despite to this advantages for the final users, interaction with 3D Virtual Environments (VE) requires different paradigms compared to the traditional WIMP approach. Organizing the information along three dimensions increases the amount of data that can be conveyed to the user but leads to a more complex interaction. New I/O technologies propose a more natural human/machine interaction. Spatial input devices and multi-sensory output technologies are being increasingly used as common components of Virtual Reality (VR) applications. Each of these devices addresses a particular sensorial channel and exhibits a different interface, see [1] for a broad review.

Multimodal 3D human-machine interaction enables the development of applications addressing users with sensorial disabilities, who can select the modality (haptic, acoustic, visual, gestures) that best fits their needs and personal characteristics. In particular [2][3][4] proved that haptic\acoustic VEs applications represent valid tools for visual impaired users.

In this context the user interface design becomes a challenging task because haptic and acoustic have to make up for the lack of visual feedback. This means that haptic and acoustic displays of 3D objects have to emulate some important features that are typical of vision. For example, vision provides the chance of seizing the overall meaning of a scene at a glance: haptic interfaces, with proper route planning, may offer the possibility of acquiring the salient parts of a scene at a first “haptic” glance. Furthermore blind users show a wider variability in terms of subjective characteristics and sensibility, so each rendering can therefore achieve different results in effectively expressing the intended informative content.



**Figure 1.** The applicative scenario

This paper presents a framework, called OMERO (Organized Multimodal Exploration of Relevant virtual Objects), for the 3D multimodal interaction with VEs. The objective covered by the framework is twofold: a haptic-acoustic VE System Interface (VESI) to allow users, especially visually impaired, to access information by interacting with 3D virtual objects, and an intuitive design tool with which C.H. domain experts, even not well grounded in 3D modeling and VEs, can associate haptic-acoustic behaviors to virtual objects in the scene. The VESI integrates well known haptic-acoustic metaphors found in literature in a unique model organized according to classical VE users' tasks such as navigation, object selection and manipulation [5], further it introduces the concept of Active Objects and a

new user task called Scene Querying. The design approach decouples the design of the VE from the design of its haptic\acoustic interface. In this way a one to many relationship can be established between a VE and its possible user interfaces. The use of an XML based schema called OMDL (Omero Multimodal Markup Language) allows to easily specify a particular interface\display combination to be associated with the virtual world. An editor tool (Editor hereon) allows the design of the 3D user interface in a visual way. The designed VE can successfully be explored by blind users using the multimodal framework OMERO. The users' feedbacks provided during the experience can be used by C. H. domain experts and by VR engineers to refine the design choices using the Editor, in an iterative and adaptive application lifecycle depicted in figure 1.

In section 2 the multimodal metaphors used for rendering VEs to blind users are presented and compared with analogous approaches used in applications of VEs for sighted users. The Editor for the authoring of the VEs user interface is presented in section 3. In section 4 experiences with blind subject are reported and finally in section 5 conclusions are drawn.

### The Virtual Environment System Interface

Not all the existing metaphors of interaction with VEs can be suitably integrated with haptic [6]. Despite this, haptic and acoustic have to make up the lack of visual display in a multimodal interaction addressing blind users. Haptic becomes a critic part of the interaction and all the graphic oriented interaction metaphors need to be revisited from a “tactile” point of view. The features of the interface have to support different tasks: navigation, objects selection, manipulation, scene querying.

In **navigation**, metaphors such as the “camera in hand” [6] require a continuous change of the point of view depending on the user movements. This frequent world reorientation can confuse blind users due to the lack of stable references points. Therefore in our approach the movement of the haptic stylus does not affect the reference system of the VE that keeps its absolute position and orientation with respect to the desk. The avatar moves in a physical workspace, whose dimensions depend on the haptic device, that the user explores by a “God-eye’s view”.

**Acoustic messages** inform the user whenever he/she enters new regions of the scene (a useful cue to support haptic navigation). A **containment box** around the scene prevents blind users from moving too far from the virtual scene, a valuable feature to prevent the user from wasting time in useless regions of the workspace and to bring him/her back in touch with the objects of interest.

A metaphor such as “Teleportation”, that allows users to be instantly moved to a given position in the scene, can disorient sighted users [7] and have a stronger effect on blind users. A smoother solution (called “small scene manipulation”) is adopted in [8]: the camera smoothly zooms in for a close-up of a particular part of the world chosen by the user. “Teleportation” and “small scene manipulation” can both be used as basic techniques to move the user avatar between two targets (target-based travel [1]). Analogously to [8], suitable attractive forces can be applied to the user hand to guide the exploration along predefined **Guided path**, a sequence of targets defined by the designer [9]. Vocal messages inform the user when a target has been reached. This haptic\acoustic rendering proved to increase the completeness and effectiveness of the mental schema constructed by blind users during the virtual environment exploration [10]. This kind of guided tour allows a preliminary coarse perception of all the relevant features of the model.

To address the problem of mapping large models onto a limited physical workspace **Dragging** and **Scaling** functionalities are provided. Two type of dragging are given: in the **Stylus Dragging** technique the user moves the whole VE model (according to the movements of the stylus) with respect to the containment box. In the **Box Dragging** technique the user moves the containment box (by pushing on its walls) with respect to the VE.

The **Scaling** technique can reduce the manual dexterity required for the correct perception of complex models. When the user requires the scaling while touching an object the VE is scaled with respect to this contact point, otherwise the scaling is made with respect to the centre of the scene. This meaningful reference prevents the user from being confused by uncontrolled movement of the environment. Similar dragging and scaling techniques can be found in [11].

The interaction (selection, manipulation and querying) with the objects in the scene requires their suitable organization and association with haptic\acoustic renderings that facilitate their perception by blind users. We defined **Active Objects** as parts of the scene conveying further information beyond their shape and geometry. They are associated with a specifically defined multimodal display (haptic force fields and/or acoustic effects). Active objects can be haptic, acoustic or haptic/acoustic on the base of the associated renderings effects (haptic, acoustic or some combination of these modalities). Active objects can be associated with a vocal message providing additional information (i.e. historical or artistic descriptions, dimensions, material, ... ). The other objects are referred to as background objects. Some active objects (referred to as dynamic) may move to enhance the awareness of components of the scene that are relevant for its comprehension (such as doors in a planimetry). This dynamic behaviour is activated on user request to avoid sudden unintentional scene modifications.

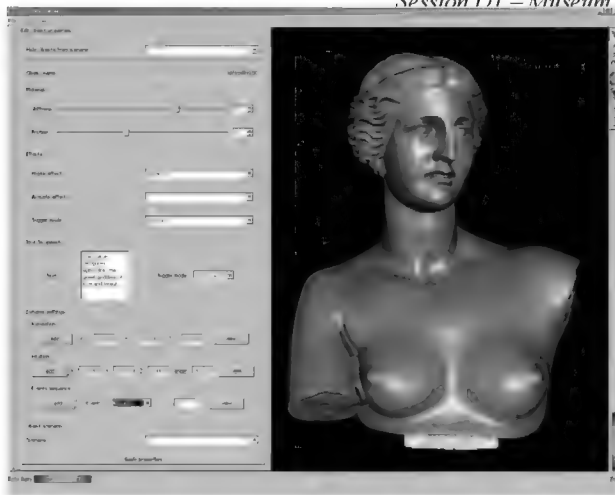
Haptic **object selection** can be done by a metaphor similar to the Ray-Casting [12], by associating attractive force fields to the neighbourhood of active objects. When the avatar is inside an attractive field, the stylus is attracted toward the object whose nature is specified by a vocal message. This technique has been successfully used to emphasize the presence of active objects in the central part of the environment (rarely visited by blind people that normally move along the borders of spaces): it can be seen as both a selection and a navigation technique.

To support **Object manipulation and querying**, each Scenario of the model at hand can be turned on and off (being or not touchable and visible). The perception of the scene can therefore be tailored to focus the attention on the data of interest in a progressive access to information. To adapt the interaction between the user and the (active) objects to individual needs, effects and dynamic behaviours can be produced under two different conditions:

- **On Touch:** automatically whenever the user gets in touch with the active object.
- **On Demand:** only if the user asks for them. The request can be made using the most suitable user interface: haptic device, keyboard, vocal commands, ... .

A complex virtual world, rich of several types of details, generates a long sequence of local sensorial data whose integration into a coherent meaningful mental schema is often a real challenge. Traditionally several physical artefacts, each representing a particular semantically consistent partial view of the real world, are used. These objects need to be explored separately to comprehend the underlying reality: an expensive process in terms of money and time. We organize the scene in **Scenarios**, views that represent semantically consistent and coherent parts of the complete information content of the scene. A scenario is a set of semantically related active objects (i.e.





**Figure 2.** The look and feel Visual Editor.

Our approach decouples “what” must be rendered (the VE geometry and structure) from “how” it is proposed to the final blind user (the multimodal interface): this is because there is not a unique optimal choice about how to convey to the users the information or the Scenarios representing a scene. Therefore, the design process must be open-ended: every rendering of a specific scene should be regarded as a relative maximum that can be improved and personalized as soon as new user feedbacks become available.

Moreover, information contents are generally decided by the domain expert, which is not necessarily well grounded in 3D multimodal design. This suggests that the structure of the user interface should be authored directly by those who are responsible for the scene contents. To account for these requirements, the Editor has been developed (figure 2). It uses contextual menus and 2D UI and allows domain experts to load a particular VE and to develop the relative user interface in terms of Scenarios, Guided paths and Active Objects and their organization.

The output of the application is an XML-based file, which follows a schema called OMDL (Omero Multimodal Description Language). This file describes “how” to render the scene geometrically detailed by a VRML file. These two files can be loaded into the OMERO framework for the multimodal experience.

### Experiments with blind users

This paragraph shows comments collected for tasks such as Navigation, Object selection/manipulation and Scene Querying.

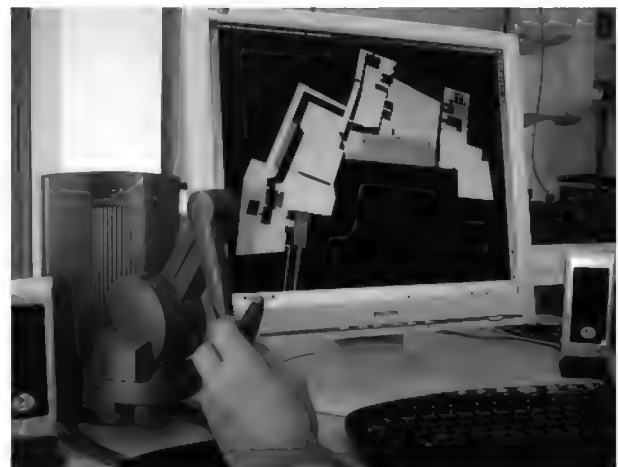
**Navigation:** OMERO has been used as a navigation tool to allow blind users to construct effective mental schema of real unknown environments. Two VE have been used: the plant of a flat and the planimetry of the Norman Swabian Castle located in Bari (figure 3). The flat is composed by a few regular rooms. The users explored the flat and were asked to construct an effective mental schema of disposition and shape of rooms. No furniture was placed around the environment. The doors connecting rooms were defined as dynamic haptic-acoustic active objects. The user could know the name of the room by hearing a synthetic voice automatically triggered whenever (s)he enters a room or on demand by pressing the stylus button. The task was terminated when the user was confident about the his/her knowledge of the flat: to verify this achievement (s)he was asked to move to the entrance of the flat from the room (s)he was into.

The VE has been explored by 8 visual impaired users, 3 females and 5 males. Two of these had low vision. All users completed the task in autonomous way except user 2 that received some suggestions to find the doors in the corridor while user 4 needed a substantial help in resuming the arrangement of the flat rooms. User 5 stated that the virtual exploration gave him a very clear idea of the arrangement of the rooms and of their relative dimensions; this information was acquired in a simpler and faster way with respect to when he explores the rooms moving along the walls for all their length, paying attention to the furniture and employing much more time and mental effort. User 8 grasped the stylus of the haptic interface with both hands and apparently moved inside the model in a confused way but, after a very fast virtual exploration, he could correctly describe the whole apartment. All but user 7 made an intense use of the button stylus to listen to the vocal messages even without waiting for the automatic ones. All the

different kinds of data available in a geographical map or different anatomical systems of an organism, ... ). The user, at each specific time, can choose a scenario and focus his/her attention only on the information associated with it, temporarily discarding all the other data. This feature can reduce the discomfort that even seeing people may experience when faced with complex environments.

### Authoring the scene

The described multimodal features must be integrated to exhibit a coherent and effective behavior in response to user requests. The scene is view as a series of Scenarios, each offering a specific semantic view of its whole information content. Furthermore, each Scenario may be associated with a guided path, which suggests a proper order for exploring its principal objects. Whenever needed the user can drag and scale the scene.



**Figure 3.** System setup: the hand of the user hold the stylus of the Phantom Desktop haptic device



users judged simple and intuitive the proposed multimodal interaction and considered the experience really realistic. User 1 referred to have the same feeling of exploring a plastic scaled model and he was certain he could successfully orientate in the real counterpart. User 4 stated he should have improved his performance by a longer training.

The VE of the Norman Swabian Castle proposed a guided path through its main points. The VE was experienced by 12 users, 4 females and 8 males. The exploration started with the guided path, composed by 17 attractive points distributed around the castle. Each user was then be allowed to move freely into the environment to acquire further details. The users were allowed to ask for vocal messages, useful whenever they got trapped in a target. Users 1, 2 and 8 moved too fast and lost some targets, but after few minutes they were able to move with the right speed. User 3, a guy with low vision, was able to reach each target by exploiting his residual sight.



**Figure 4** The model of the Apulia region with the main cities and the principal roads between them

User 4 claimed that this type of guided path should be integrated with vocal messages informing about the next direction to be taken. User 5 paid much attention in asking for vocal messages whenever she reached a new target, and claimed that this type of functionality could be very useful when exploring unknown environments. User 10 followed the path in a very systematically way, his velocity allows him to feel every target, he claimed that more visits could enhance the comprehension of the targets displacement and during the free exploration his movements followed the direction dictated by the guided path. Analogously results were observed for users 12 and 13 while user 11 was a blind/deaf girl unable to exploit the vocal messages: her visit was more confused and not very aware.

**Object Manipulation and selection:** During the navigation in the flat and in some rooms of the castle, users interacted with active objects such as the doors (modeled as haptic-acoustic dynamic active objects), speaking walls (informing on demand about the

environment), attractive objects highlighting the presence of some type of important objects placed in the middle of the environment. Users interacting with doors were able to perceived the vibration and to learn how to open them after few trials. Some users had problems in opening doors (an operation triggered on demand by pressing the stylus button of the haptic device while the probe is in touch with the door) because the pressing movement pushed the probe away from the door breaking the contact. Other users found difficult to move across the door after its opening. In the castle haptic active objects were inserted to highlight artifacts placed in the middle of some environments in the real site. The active objects exerted an attractive force to the avatar whenever it came close. The interaction with this type of objects resulted effective for some user and quite irrelevant for other: users that moved at an higher speed failed more often to feel the attraction and found objects only when they collided with them. Slower users felt the attraction, reached the object and could trigger vocal messages about the object by pressing the stylus button.

Other type of active objects was only acoustic, and they act as informative points about geometries and history of the environments. The vocal messages could be triggered on touch or on demand. The experiences suggested that vocal messages triggered on touch can confuse the user, because their activation was not necessarily wanted by the user but could be generated by an accidental touch of the avatar. For this reason all these types of objects are activated on demand, by clicking on the stylus button. A user claimed that geometry explanation should be given before the navigation of the environment to provide a first idea of the room shape.

**Scene Querying:** The virtual model of the Apulia region has been constructed on the basis of GIS data. The model is multi-layered, therefore it is possible to simply switch among many different versions, each containing a particular semantic level of information. A first level concerns the shape and the disposition of the provinces, their borders and the borders of the region with the other regions and the sea. A second information level reports the hydrographic network of the region. Further information regards the disposition of the major towns. Finally, the last scenario shows the main road connections between towns and it is depicted in figure 4.

The described model has been proposed to 7 visually impaired users, five totally blind, and two with low vision. Some of them did not have any previous knowledge about Apulia. Users started their test exploring the first level of the model to acquire the mental shape of each province and of the whole region, their borders, names and the relative position. Then they went through the next levels, pressing the function keys on the keyboard. Only two people were not able to explore all the scenarios: the first had some motor disability while the other one, with a low residual vision, found difficult to concentrate on the haptic rendering and on the acoustic suggestions. People that had some previous knowledge of the region found easily rivers, lakes and towns while people with no previous knowledge were able to learn in an alternative way new information and found the haptic-acoustic interaction really effective.

The switching mechanism among Scenarios did not annoy users during their exploration and it resulted quite transparent. Appearing and disappearing objects did not confuse users as long as they were informed about the particular informative contents of the Scenario. The majority of the users found that this way to organize information allows a more comfortable and effective learning. Only user 5 complained about the loss of reference points (common objects) between Scenarios: for example the presence of towns could have been a useful orientation tip when exploring rivers and lakes, suggesting the opportunity of merging information from several Scenarios.

## Conclusions

A framework to allow visually impaired people to access informative contents by a multi-modal interaction with Virtual Environments has been presented. It uses the haptic technology to extend the visual and auditory interactions with the sense of touch. This extends the experience of VE and makes possible an effective and efficient interaction with virtual 3D scene even for users with sensorial limitations such as blind people. For this kind of users the haptic-acoustic interaction and a controlled and progressive access to the representation of the real world have proved to strongly help the construction of a mental schema of the proposed scenes.

Despite the increasing number of research projects in the field of multimodal VE for visual impaired, no standards are available for haptic-acoustic 3D user interfaces: several different interaction metaphors have been developed and applied. Moreover, blind users show a wider variability in terms of subjective characteristics and sensibility: this significantly affects how much the intended informative content is effectively expressed by a particular rendering. The presented framework offers a twofold solution to these issues: a unified VESI that integrates a wide variety of different interaction metaphors, coming from the literature or validated by our past experiences. Moreover it provides a large flexibility in matching the rendering to specific user needs. The metaphors are thought to help blind users in classical VR tasks such as Navigation, Object Selection/Manipulation and Scene Querying.

Furthermore the approach exploits user feedbacks to refine the design choices about user interface and haptic-acoustic effects used to multi-modally render the scene. To reach this goal, the descriptions of the VE geometric structure and of the user interface are decoupled, with the latter described by an XML schema. In this way a single VE can be associated with a large number of different renderings tailored to specific individual user needs. Moreover the design of the interface and the composition of its description in the XML format are made through a Visual Editor. It loads the scene graph associated with the VE and, if needed, makes the modifications required to fully implement the logical components of the desired rendering. Such simple visual tool allows also domain experts without specific knowledge and skills about virtual reality to define the rendering best suited for their specific communication goal.

A large number of experiments with blind users, even in the context of C.H., have shown the effectiveness of the implemented VESI for users tasks such as Navigation, Object Selection/Manipulation and Scene Querying. For Navigation virtual guided tours have proved to help blind users to acquire a first coarse schema of the salient areas of the site and vocal messages (mainly triggered on demand) have provided useful cues to support way finding. Also low speed and a systematic use of the vocal messages enhance the user comprehension of the scene. Active Objects have demonstrated to convey information, usually given with Braille captions, in a more effective and compact way using synthetic vocal messages. The mechanism of scenarios, that divide the information of a scene depending on its semantics, has been well accepted and has proved to be effective: blind users have acquired complex information in a more comfortable and gradual way achieving a better understanding and organization. A future goal is the dynamical proper merge of data related to different Scenarios into a single new view to answer specific User Queries that can benefit from this purposive integration.

The main goal of the system is to offer a flexible tool to communicate complex contents to users, even with visual impairment. The domain expert and the people with specific preparation about the cognitive effects of this sensorial limitation are the best responsible of the design of a successful strategy of communication with these final users. The developed visual editor allows them, even if they lack a strong background in virtual reality and technology, to design the characteristics of the multimodal rendering. This valuable feature shortens and simplifies the communication between the originators and the receivers of the cultural contents, opening a wide range of possibilities to find the best match between the communication goals of the designer and the personal characteristics and capabilities of each user.

The system has been proved on application related to the fruition of cultural heritage, the communication of features of a territory, the teaching of base concepts in geometry. These tests exemplify only a small range of possible applications: any context involving the interaction with 3D structures can benefit from its use. Future work will deal with didactical applications (mathematics, arts, history, geography, chemistry, biology, physics, ...) as long as daily tasks such as fruition of digital contents on the web, mobility (planning route, knowledge of city maps, planimetry of sites or public places or offices, ...) and tourism.

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## **THE POTENTIAL FOR AN INTEGRATED AND ‘MULTIVOCAL’ INTERPRETATION OF THE SHARED PAST WITHIN THE WORLD HERITAGE SITE OF GÖREME, CAPPADOCIA.**

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**Keywords:** Byzantine churches, tourism, tour guides, WHS, cultural change

The Byzantine history of the World Heritage Site of Göreme (inscribed 1985) has become embedded as the dominant narrative and key historic period interpreted within the ‘open air’ museum. Focusing on the Christian nature of the site endows it with international legitimacy which enables it to attract large numbers of Western tourists. Museums have traditionally ‘fixed’ ideas, attitudes and ‘truths’ into a moment of time, however this politics of representation impacts on both the interpretation and the tourist experience. By emphasising this Byzantine past formally trained local guides, who are invariably drawn from other faith communities, are highlighting how cultural memory and identity shaping can operate within tourism as a powerful discourse, silencing certain narratives about the past and privileging others. This interpretation impacts on local individual or communities' sense of ownership of the past, as well as on tourists understanding of present day life within the region. Moreover, discussions with local guides suggest there is an expectation that, as a Christian site, it will be experienced by tourists as a place of pilgrimage. This renders other interpretations problematic. Drawing on fieldwork carried out in September 2009, and drawing on Tucker’s longitudinal study of the region, this paper examines how the site is interpreted, including exploration of attitudes to and knowledge of the Christian scenes depicted within the cave structures and the time frame explored within the representational framework. Thereafter, we argue that Cappadocia, as a designated World Heritage Site, has the potential to offer a more ‘multivocal’ interpretation that embraces the more recent history, thus allowing locals and visitors alike to develop a fuller understanding of religious, social and cultural change as it impacts on identity shaping within the modern world.



## FERRARA - PALAZZO SCHIFANOIA – THE SALA DEI MESI

**PIERO CASTIGLIONI\***

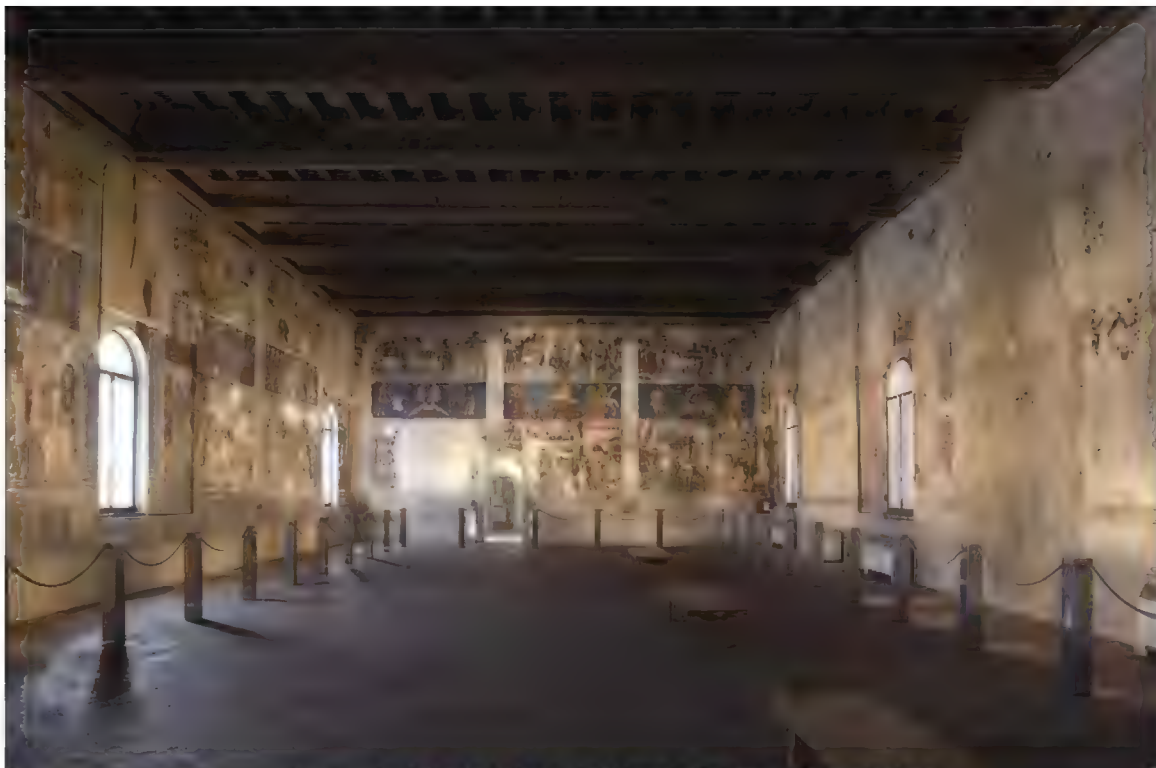
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During the second half of the 15th century, Borso d'Este commissioned a cycle of frescoes from the leading painters of the *officina ferrarese*, which are among the foremost examples of profane art originating from the Italian courts of the Renaissance.

The **Sala dei Mesi** is a rectangular hall with a notably high coffered wood ceiling (6.2 metres approx) presenting a succession of large historiated transverse beams. The longitudinal walls (one with the frescoes well preserved, the other showing only faint traces of the former decoration) are punctuated by a set of windows; the frescoes on the transverse walls — one with an entrance door, the other with a door leading to adjacent rooms — are severely degraded at one end of the room, and in a better condition at the other.

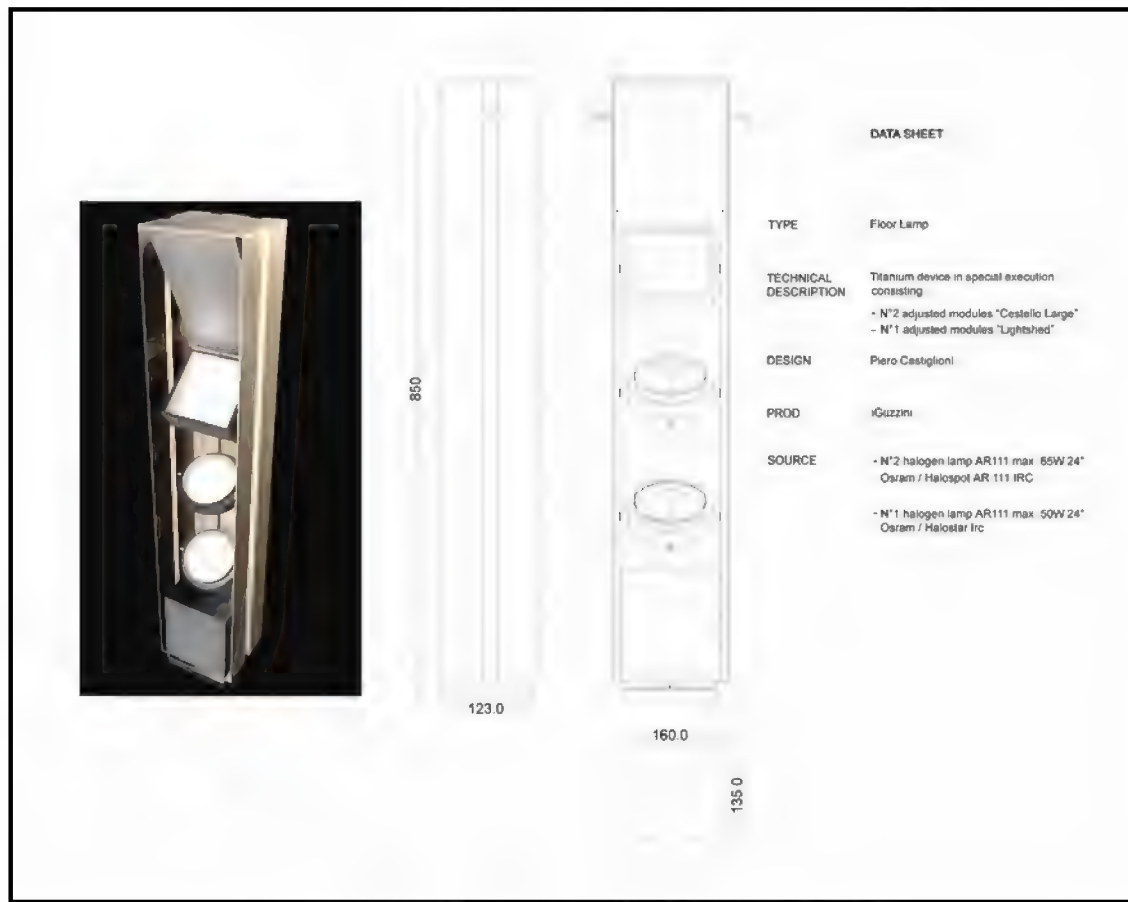


**Figure 1-** Sala dei Mesi - Schifanoia Palace - General view

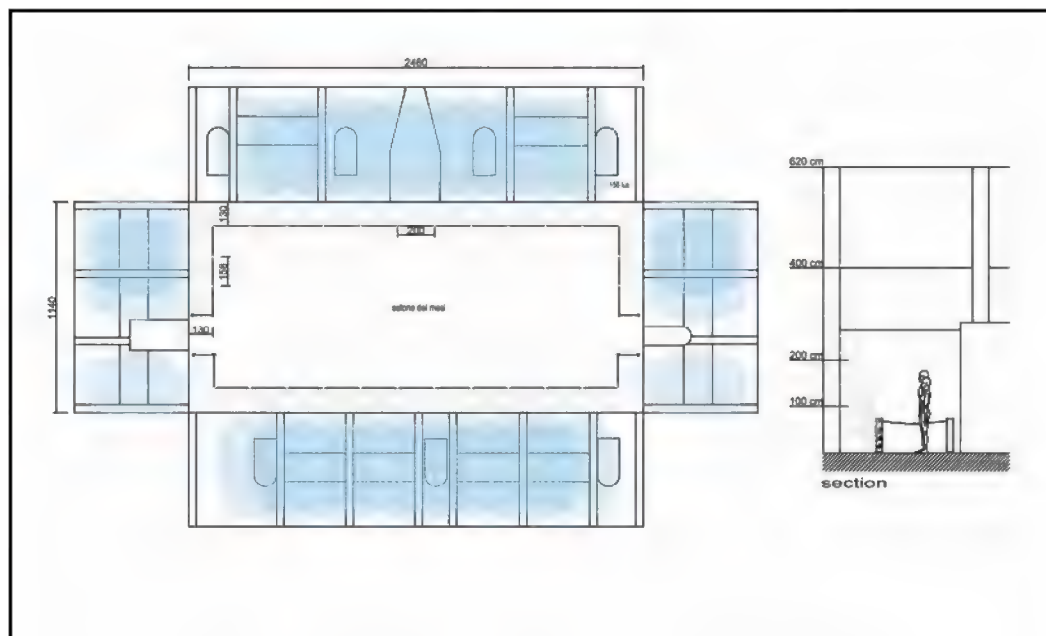
The space enclosed by the room, imposing in every sense (materials, dimensions, decorations) is flooded uniformly with natural light, at low levels of illuminance, entering through the windows and reflected off the floor. A system of light-diffusing curtains would be adopted to eliminate the projection of the window images onto the floor and give the entire interior a quiet sense of order.

Our proposal for the general lighting of the Sala, and of the frescoes representing the cycle of months and scenes of life at the Estense court, consists in a single, specially created direct lighting appliance of new design:

- a column (85 cm high) with a rectangular base, made of titanium (a metal with little or no heat conduction properties), balanced with a lead counterweight to ensure stability, anchored to the floor with a masonry plug, equipped with a rubber foot to create friction and increase stability, and housing the necessary items of equipment (image 2) (image 3)



**Figure 2** - Data Sheet Lighting system



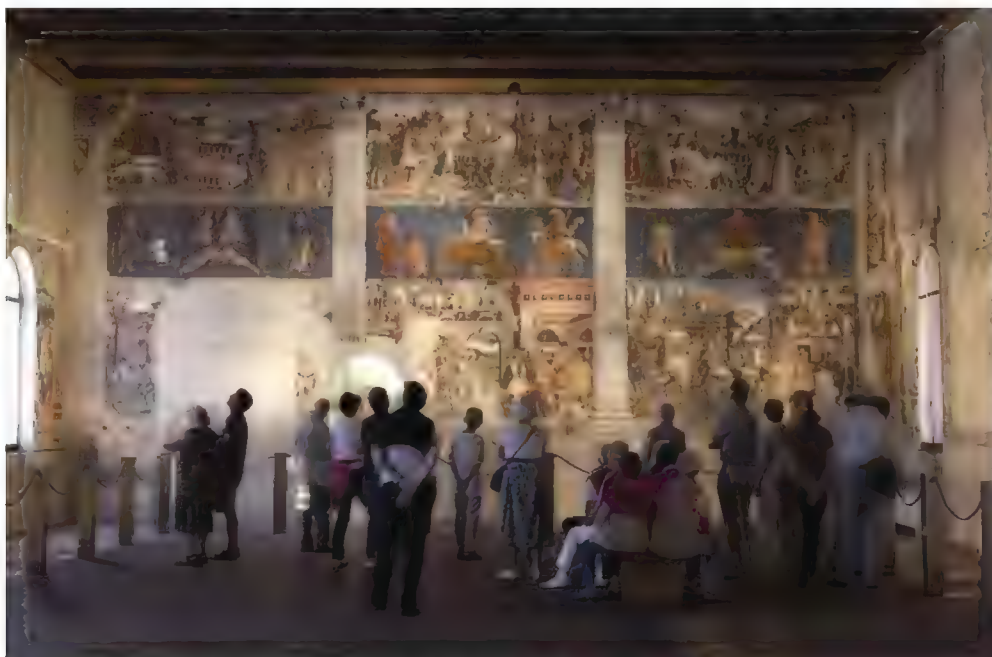
**Figure 3** - Sala dei Mesi - Schifanoia Palace - Lighting project

*Mise-en distance*: provided by the through power cable, which also serves as a visual connection between the column elements (giving them continuity in space and rendering them a single entity), besides functioning as an effective barrier for the purpose of ensuring visitors are kept at a safe distance from the vulnerable frescoes.



**Figure 4** - Sala dei Mesi - Schifanoia Palace - Lighting system

The distribution of the luminaires (28 columns) around the periphery with no break in continuity, and the appropriate directional orientation of the light sources — completely concealed from the visitors' view — guarantee illuminance values of the order of 150 lux on the walls, evenly distributed, with colours and paint shown up to optimum advantage, without shadows and reflections, and generating minimal visual impact. (image 5)



**Figure 5** - Sala dei Mesi - Schifanoia Palace



## CULTURAL HERITAGE AT THE UNIVERSITY OF PAVIA: FROM HISTORY TO FUTURE.

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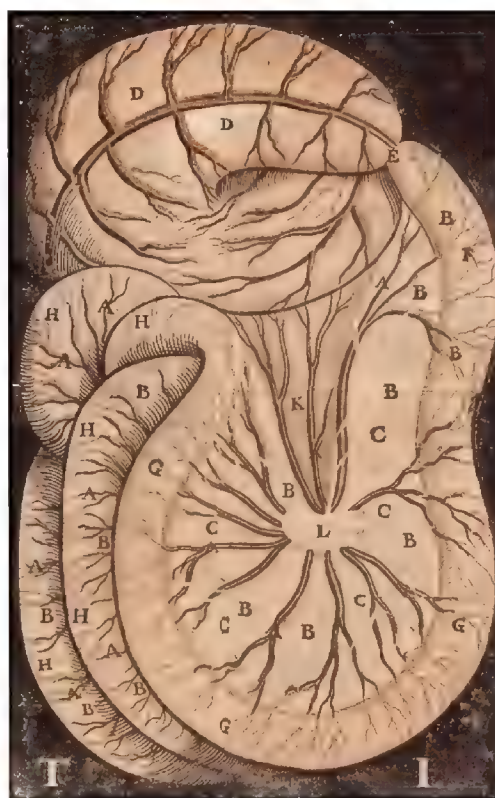
e-mail: [alberto.calligaro@unipv.it](mailto:alberto.calligaro@unipv.it) - Museum web site: <http://ppp.unipv.it/musei>

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**Keywords:** History of Medicine, Pavia University, Golgi, Scarpa, Volta.

The University of Pavia is one of the oldest universities in Europe. A higher education institution in Pavia was already established in 825 by the longobard king Lotharius. Chosen as the main education centre in northern Italy, after enlargement and renewal by Gian Galeazzo Visconti duke of Milan it became the University of Pavia officially established as Studium Generale by Emperor Charles IV in 1361.

The historical roots at the basis of modern methodology, with Lazzaro Spallanzani, Alessandro Volta, Antonio Scarpa, Camillo Golgi, scientists well known for their discoveries, are clearly demonstrated through the rich collections of documents, preparations and instruments of the Museum for the History of the University of Pavia [1]. From the first documents of 14<sup>th</sup> century, the Museum intrigue the visitors with the manuscripts and publication by Gaspare Aselli of 17<sup>th</sup> century (Fig.1 a, b) [2,3] and the documents and objects regarding Natural Sciences by Lazzaro Spallanzani. The anatomical theatre (Fig.2) as well as the very finely preserved original preparations of anatomy by Antonio Scarpa, as paradigms of the new anatomy both in research and in surgical applications [4], represent a mirror of the knowledge in the second half of the 18<sup>th</sup> century, together with the electric instruments by Alessandro Volta, as electrosopes, electrometers and the electric battery (Fig.3).

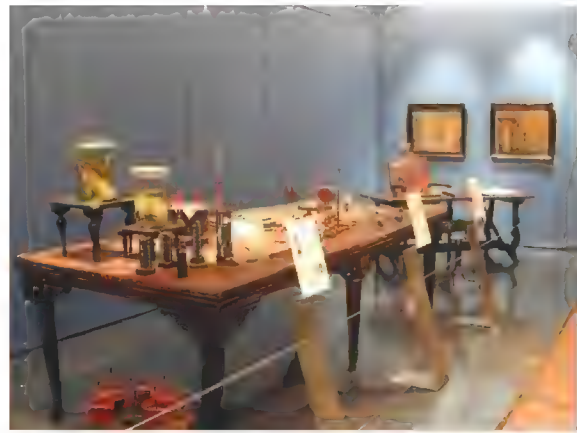


**Fig.1** - Title page of the book (a) by Gaspare Aselli (1627) and table (b) demonstrating the discovery of chyliiferi (lymphatic) vessels.





**Fig.2** - Top of the Anatomical Theatre entititled to Antonio Scarpa (1783).

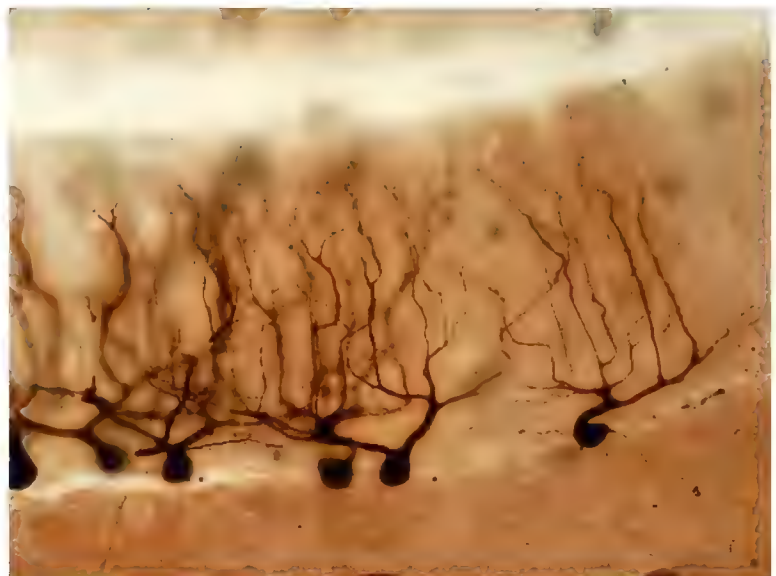


**Fig.3** - Alessandro Volta working table.

A specific section is devoted to Camillo Golgi (Fig.4), winner of the 1906 Nobel prize together with Santiago Ramón y Cajal for his invention of the black reaction on neurons and the studies on the fine structure of the nervous system (Fig.5) [5,6,7]. Camillo Golgi also studied malaria (Fig.6) [8] and, in 1898, discovered the so called Golgi apparatus (Fig.7) [9], a cytoplasmic organelle today known playing a central role in secretion and in the dynamics of renewal of cell membranes.



**Fig.4** - Camillo Golgi room at the Museum.



**Fig.5** - Cerebellum Purkinje cells stained by Camillo Golgi black reaction

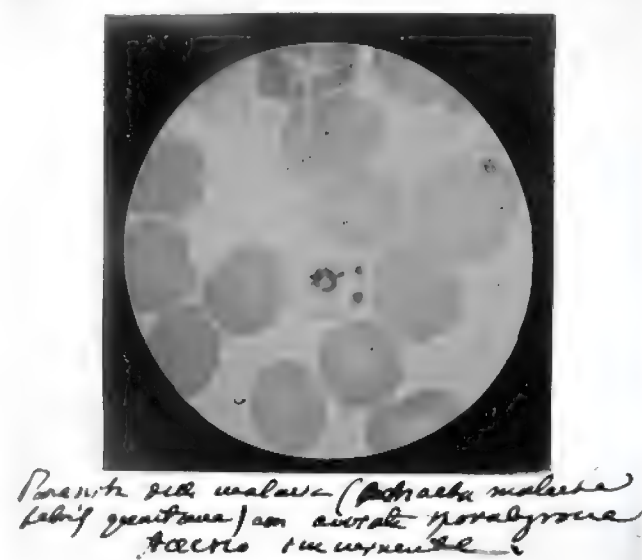
Today the University of Pavia as a Research University is one of the leading Institutions in Europe with teaching activity closely related to research. It is offering a wide variety of disciplinary and interdisciplinary courses organized in 9 Faculties.

Colleges for university students were also established since the 16th century. They are now 16 offering to the best 2.000 students of the University a unique opportunity of study and cultural enrichment in a multidisciplinary and multiethnic environment.

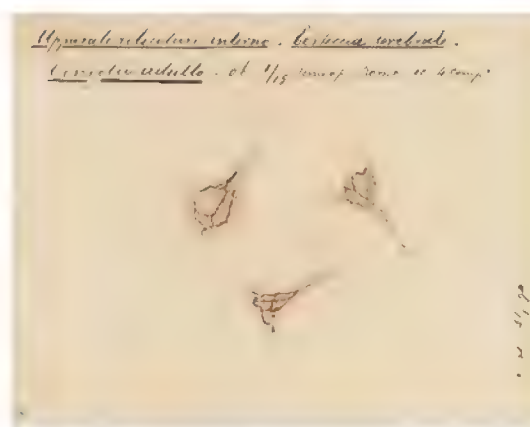
The international vocation is underlined by the attendance to the University of Pavia of pre- and postgraduated students from many countries, mainly coming from the mediterranean area.

The educational system in scientific faculties is based on a close link between a strong basic science education and effective on-the-field applications. A high regard to internationalization is demonstrated by the starting in 2009 of 3 degree courses in English including a degree course in Medicine and Surgery, unique in Italy.

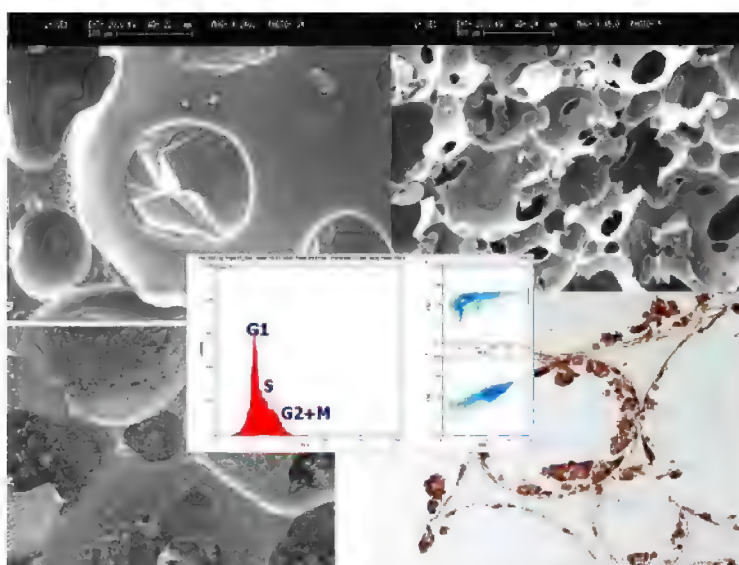
In the Faculty of Medicine and Surgery a highly qualified activity both in basic science research and in clinical applications is performed with consolidated competences in many areas, particularly in cell and stem cell biology, tissue engineering (Fig 8) [10,11,12], biomolecular science and biotechnology, genetics, pharmacology, physiology, hematology, pediatric oncology, gastroenterology, nephrology, molecular cardiology, orthopedics, cardiac surgery and organ transplants, neuroscience and environmental health.



**Fig.6** - Golgi apparatus: original drawing by Camillo Golgi.



**Fig.7** - Malaria. Sporulation in a blood eritrocyte



**Fig.8** - Tissue engineering. Bone tissue cells growing in 3D scaffold.

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## DIGITAL HIGH – RESOLUTION MACROPHOTOGRAPHY OF NON PLANAR OBJECTS

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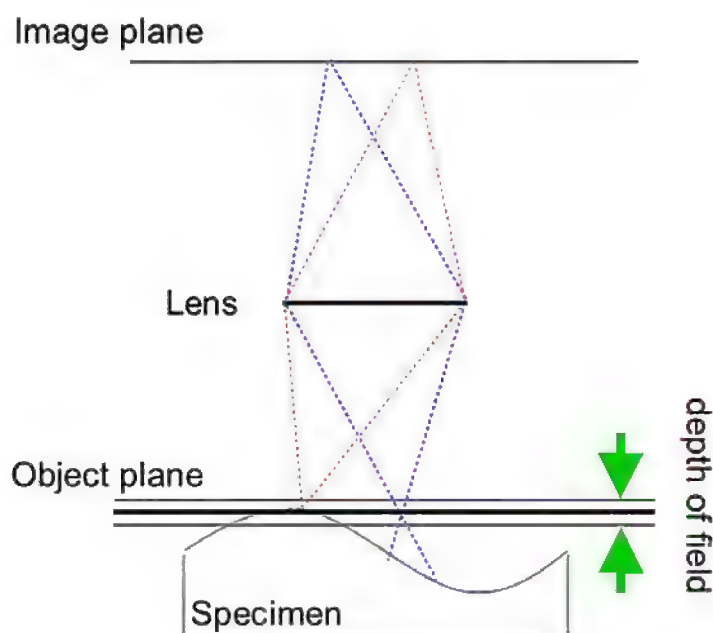
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**Keywords:** macrophotography, depth of field, focus stacking

### 1. Introduction

Digital photography is rapidly replacing traditional film photography in the field of Cultural Heritage. Digital images can be examined immediately and image-processing techniques are commonly used to improve their final quality. Dark-rooms are getting obsolete and many have already been closed. This process is now more and more evident as digital-backs, with an ever increasing number of pixel, are getting available on the market.

Digital photography also opens new perspective, e.g. for what concerns macrophotography. Specific techniques to shoot and process macrophotos allow to store images with unprecedented depth of field (DOF). DOF is defined as the range of depth within the subject that is acceptably sharp, Fig. 1.



**Fig 1** - Depth of field

Techniques for extended DOF, formerly developed for other applications, would be of great help for study and restoration purposes of Cultural Heritage.

### 2. DOF in macrophotography

Macrophotography is used whenever a high-resolution documentation of a surface is necessary. The documentation of the various steps of a restoration, for example, consists in a series of photographs, the higher the resolution the better. Very often these images are shot in the range of close-up and macro-photography, i.e. focusing down to about life size. The main problem shooting non-planar objects at such close range in a traditional way, is that the required DOF cannot be achieved even setting the diaphragm at a small aperture, other than the fact that diffraction would degrade the image sharpness.



It is important to point out that focusing at 1:1 with a hand-held camera, the maximum size of the viewed object will be that of the CCD, i.e. 24 x 36 mm for the best cameras. Using digital backs for larger format cameras, the maximum object height is about 50 mm. At this magnification, or at a slightly lower one, the DOF is too shallow and the maximum resolution of the CCD cannot be exploited except for flat objects. Focusing at 1:1 with a macro f 100 mm lens and diaphragm set at f/8, the DOF is remarkably less than 0.5 mm, depending on the lens design, and traditional macrophotography is useless in most circumstances. No use stopping further down the aperture because any possible gains in DOF are offset by diffraction. Techniques like “focus stacking” may help solving this problem.

### 3. The focus stacking technique

The technique of “focus stacking” is a shooting and image post-processing technique to artificially increase the DOF in close-up images. This method, formerly developed for micro-photography [1], consists in taking a series of images sliding the focal plane throughout the object’s depth from the foreground down to the background. The stack of images is then processed to assemble the area in focus of each image into a single composite, perfectly in focus over the full depth of the object.

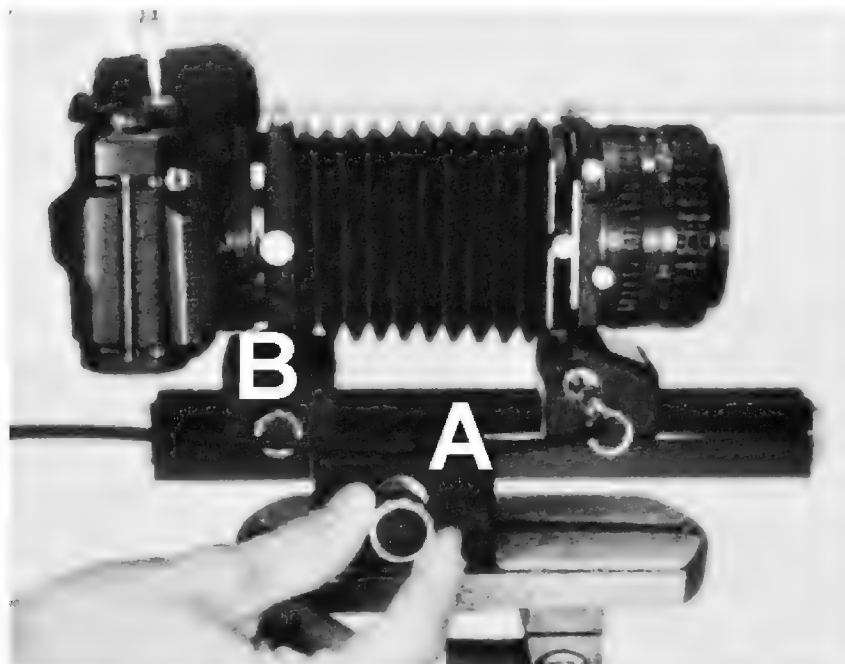
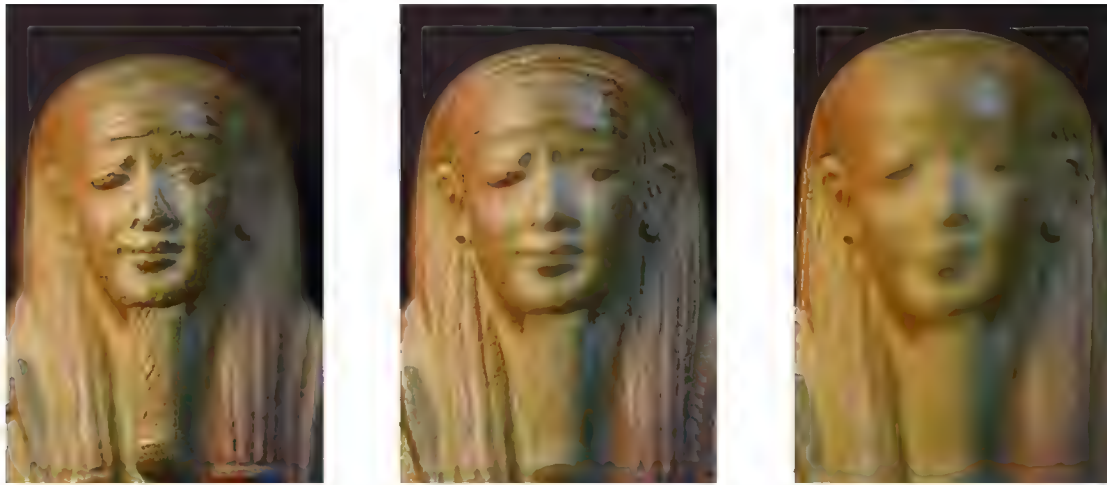


Fig 2 - Typical macro system

A typical macro system allows different ways to move the focus. It consists of a camera, a bellows and a lens mounted on a focusing rail, as shown in Fig. 2. Turning the knob A the entire camera/lens assembly is shifted and the magnification is the same all across the object, i.e. for all the images of the stack. Turning the knob B only the camera moves and the magnification changes for each image. This is also true when a macro lens is directly attached to the camera and the focusing is achieved rotating the lens barrel. It is worth reminding here that moving the entire camera/lens assembly of a certain amount, one shifts the focus of the same amount while this is not true when only the camera is moved, or the lens barrel is rotated. In other words the relation between camera movement, or barrel rotation, and focus shift is not linear. A sturdy and precise rail should be used that allows an accurate shifting of the photographic equipment in order to store a stack of aligned images.

### 4. Preliminary tests of the focus stacking technique

To test the technique we first proceeded to examine some objects of increasing difficulty. The first was a small head of an ushaby statuette ( non original ) moderately glossy and smooth. We used a traditional macro set up, i.e. a hand-held camera, a bellows and a f 100 bellows-lens. The magnification was set 1:2 and a stack of 13 images was recorded moving the entire system. The 1st, 7th and 13th image of the stack are shown in Fig. 3 and the final composite in Fig. 4.



**Fig 3** - 1st, 7th and 13th image of the ushabty stack



**Fig 4** - Composite of the ushabty stack

The second object, a small fossil shell, was chosen because of its shape and particular texture. It was oriented slightly pointing towards the lens in order to increase the depth and let some parts hide other details. A 34 image stack was recorded, see Fig.5, and different processing algorithms were used to build the composite. A complete discussion and comparison of the different algorithms is beyond the scope of this paper and will be described elsewhere. It is important to point out here that the final image of this rather complicated object, and of other similar ones, showed some halos or fuzzy edges depending on the algorithm, the object shape and the texture characteristics of the object and of the background. These minor defects are so small they are only detectable in enlarged prints and cannot be reproduced here. They were easily and manually emended and an example of the final image is shown in Fig. 6. The reason why they happen is that in many cases the rails of commercial macro systems do not perform movements as accurate as required by the small dimensions of recent CCD pixels. Images in a stack are therefore likely to be slightly misaligned and/or rotated and the processing software may not emend efficiently these mishaps.



**Fig 5** - 1st, 18th and 34th image of the fossil shell stack



**Fig 6** - Composite of the fossil shell stack

## 5. Two processional crosses

Details of two processional crosses were documented with the focus stacking technique, the first belonging to the Ospedale Maggiore in Milan and the second to the Iglesia de S. Maria Magdalena de Tibi in Spain. The first one is gilded while the second is silver.

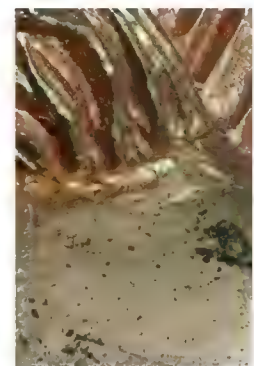
Fig. 7 shows three images of a stack of 36 of a detail of the first cross and Fig. 8 its composite. The resolution of this composite allows large magnification reproductions as shown by the crops of Fig.9. These images clearly document even the smallest surface characteristics and defects such as pitting points.



**Fig 7** - 1st,18th and 36th image of the stack. Angel symbol of S. Mathew, processional cross Ospedale Maggiore Milan



**Fig 8** - Composite of the stack of Fig 7



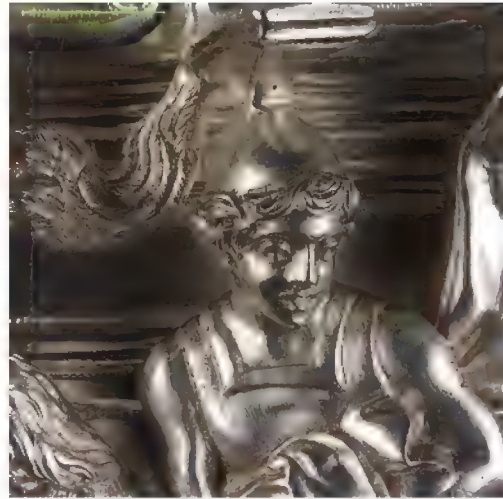
**Fig 9** - Expanded crops of Fig 8

Fig.10 is a particular of the silver cross representing S. Martin. A stack of 35 shots was recorded and processed. A detail of the final composite, Fig. 11, shows how all the planes of the scene are in focus. The high resolution in the final result is clearly demonstrated by the two crops of Fig. 12 where the mode of finishing is well distinguished.

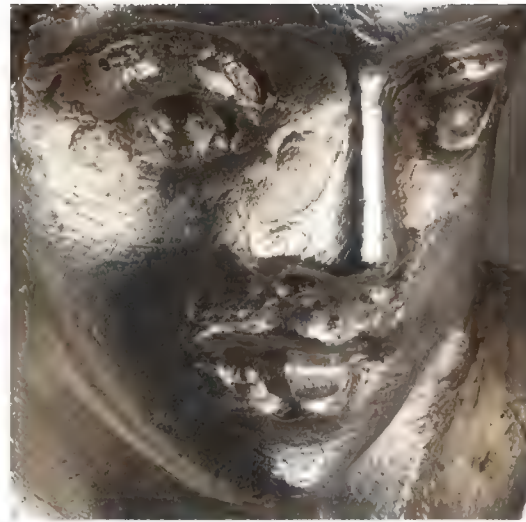
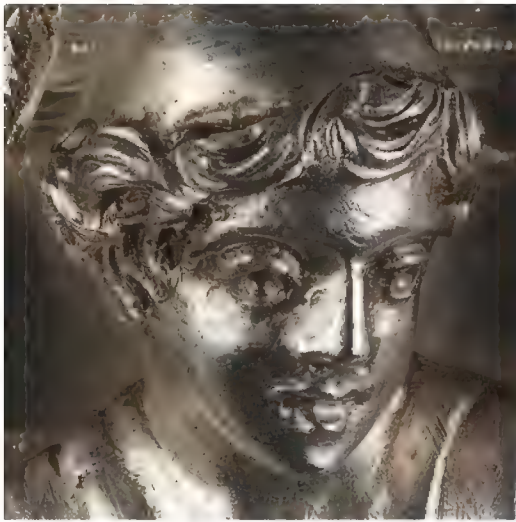




**Fig 10** - S. Martin, particular of the valentian cross



**Fig 11** - Composite of a detail of Fig 10



**Fig 12** - Expanded crops of Fig 11

## 6. Conclusion

The focus stacking technique deserves particular attention because of its potential not yet fully exploited. Though quite simple in principle, its extension to the field of Cultural Heritage is not straightforward. The difficulties are mainly due to the fact that here the objects to be examined can vary a lot for what concerns dimension, material, depth of relief etc.

A joint research project is now being carried on by the experts of the *Centro di Riflettografia I.R. e Diagnostica dei Beni Culturali* dell'Università degli Studi di Milano, the *Instituto Valenciano de Conservación y Restauración de bienes Culturales - Castellón* and the *Musei Civici* di Milano, to study the various possible applications of this method and to design a system with different lenses and digital backs for the automatic storing and process of image stacks.

## References

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# THE EVALUATION OF ACOUSTIC CHARACTERISTICS OF MUSICAL INSTRUMENTS AFTER RESTORATION

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## 1. INTRODUCTION

Many museums of musical Instruments hold collections of ancient and rare Instruments, which very often are damaged. Sound characterisation, preservation, utilisation of quite particular Instruments represents a still unsolved question, and different world institutions give not-univocal answers to this matter.

Usual technology gives just an overview of the physic characterisation of the sound chests of violins or the bodies of flutes or trumpets, and there are no easy possibilities to rendering "sound quality" of ancient Violins without building a *replica*.

In this research the sound characterisation of ancient musical instruments through a virtual non-destructive methodology is investigated. Taking into account the acoustic behaviour of soundboards and bells of instruments, considered as linear system, the acoustic characterisation of string and wind instruments has been analysed.

By measuring the impulse responses of ancient violins and of wind instruments, like flutes of different material and trumpet of the baroque age, the sound quality of their sound chests have been replied. Following this technique, also musical Instruments heavily damaged or not more existing could be "virtually" played.

## 2. THE VIOLINS

To get the acoustic characterisation of the musical instruments it is necessary to measure the impulse response of the whole body. In the case of violins the instruments were placed in the anechoic chamber of the Cremona Violin Making School, fitted with proper supports, microphones and preamplifiers, and the measurements were performed as shown in figure 1.

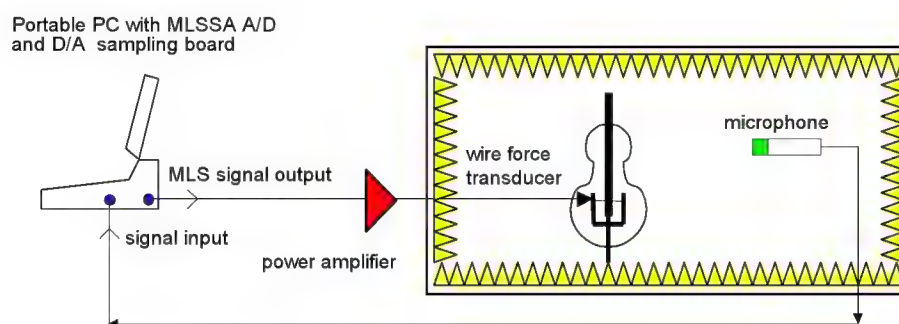
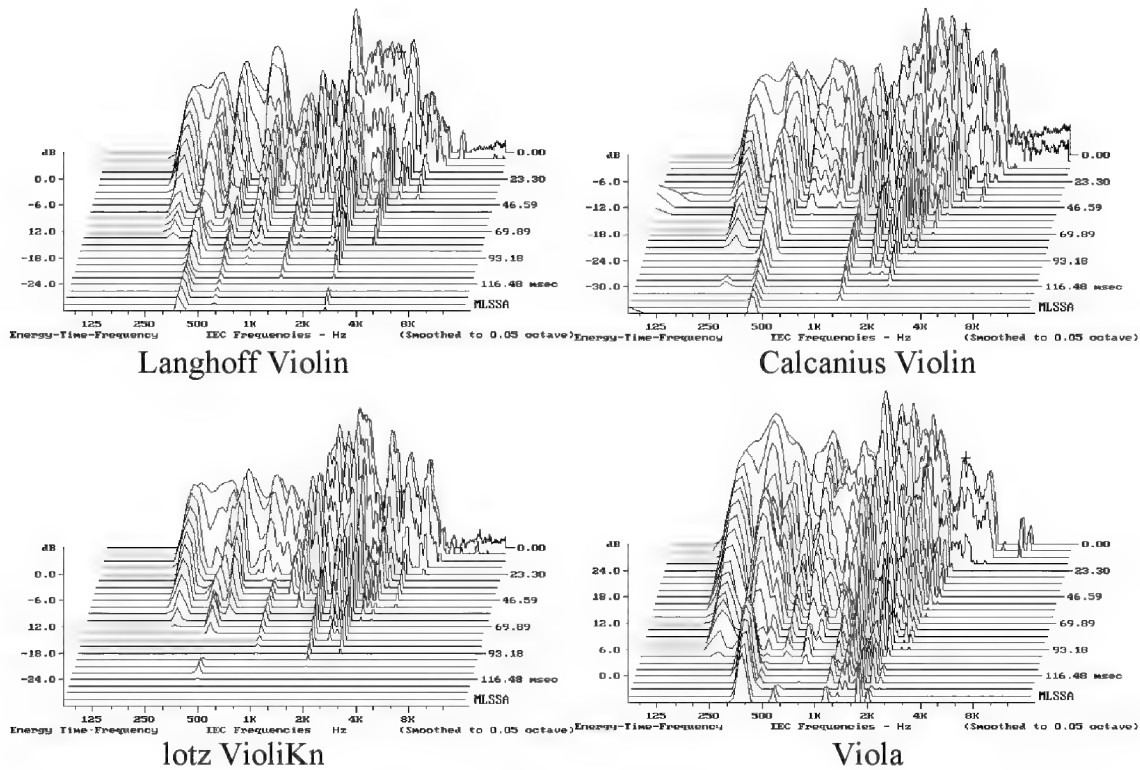


Figure 1: schematic measuring system for measurements on violins

The impulse responses of three violins, namely "Calcanius", "Klotz", "Langhoff" and of one viola were measured. The viola was introduced only to have a very different instrument, making audible to everyone the different timbric coloration. In the anechoic chamber a short performance "on one string" were recorded.

From the time-frequency responses of the 4 instruments it can be observed that the viola is noticeably different, whilst the differences between the three violins are not so clearly evident from these waterfall representations.



**Figure 2:** Energy-Time-Frequency responses of the four string instruments

3.

#### 4. THE WIND INSTRUMENTS

The wind instruments usually are considered very hard instruments to be analyzed, owing to the interaction of vibrations, blowing, and viscosity of the air that characterize the sound propagation. Virtual characterization avoids almost all these difficulties.

The recordings have been conducted in near acoustic field, close to the trumpet, and the approximate inverse IR have been obtained by meaning of Toeplitz (and Kirkeby) method. In a second step, by convolution with the inverse filter, the “anechoic” music has been obtained and then colvolved with other IRs.

##### 3.1. FLUTES

The influence of material and obsolescence in sound quality on flutes is well known among musicians [2]. It is well known that a “gold flute” *sounds* better than a “alloy flute”, though it is not well established where the difference lies.



**Figure 3:** the set-up for the measurements on flutes

In order to point out sound characterization of the instruments, two different flutes were analyzed, namely a Bundy (a nickel silver and copper alloy), and a Muramatsu (silver metal only). The first one was an obsolete instrument, while the second a quite new flute.

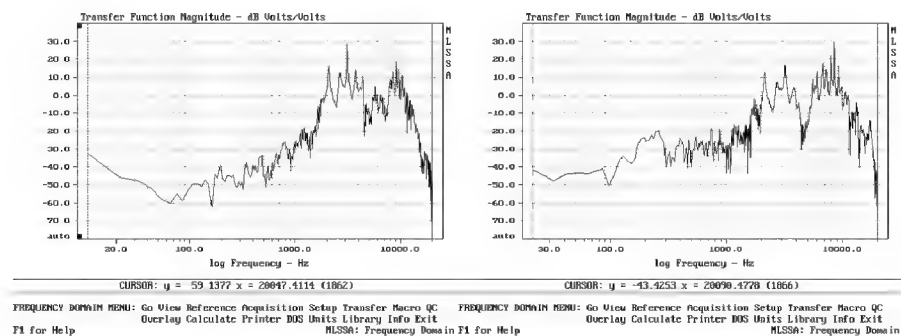
### 3.2 TRUMPETS

Considering trumpets, there are sound quality modifications due the modifications on valves and weights from each trumpet. To check these differences measurements have been conducted on three different trumpets, namely Vincent Bach, tuned in C; Yamaha, tuned in B-flat, and Yamaha Custom, tuned in B-flat at the upper octave [3]. The first two trumpets are quite much alike, while the last one is quite different, both in shape and in sound timbre. The measuring points considered in each instrument, covered almost all the bore. They have been chosen with a step of 5 mm each other, beginning from the flaring bell until to reach the cylindrical tube.

The frequency responses of the trumpets have been calculated from the experimental impulse responses. In a first step, the frequency responses have been compared among the different positions in the flaring bell.

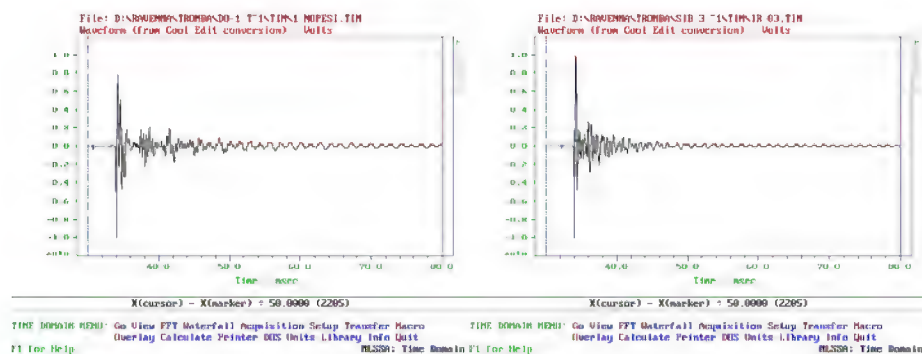
## 5. ACOUSTIC MEASUREMENTS

The measurements of IRs showed the differences in time domain between the two flutes, being the first one (Bundy) slightly more “reverberant” than the second one (Muramatsu). In the frequency domain, the IRs of the two flutes were characterized by a different component at high frequency, where the silver flute had slightly more partials than the other one (Bundy). Such difference is remarkable, and clearly audible by listening to the different IRs. It was also noted that not significant differences were found, either in time domain or in frequency domain, by changing the position of the microphone.



**Figure 4:** TFs (from IRs): flute “Bundy” (left) and Muramatsu (right)

From the analysis, a slight difference in frequency response has been found especially at the higher frequencies, where the flaking bell sounds more evidently.



**Figure 5:** Trumpet “Vincent Bach”, model 229 C1 (in C) (left) and “Yamaha Custom”, model 9830 (in B-flat, upper) (right)

The reconstruction of sound characterization of the trumpet by using MLS technique gives the possibility of comparing different instruments of different characteristics and/or material, avoiding all non acoustical phenomena, as already found in string Instruments, i.e. violins. Slight differences have been pointed out by making measurements in the trumpets, coming from inside the tube to the flaking bell, in which the frequency responses of the instruments decreased, and by applying weights on the valves.

## 6. CONCLUSIONS

The virtual reconstruction of musical instruments gives the possibility to fully-characterise the soundboard of violins and wind instruments without using damaging techniques. Furthermore, it is possible to reproduce how they could really *sound* giving more possibilities to museums to make them available to a wide number of users.

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- [3] Tronchin L., Cocchi A. (1999) in *Proceedings of Forum Acusticum99* (Morain E. ed), Berlin, 67-84
- [4] Tronchin L., (2005) *Journal of Acoustical Society of America*, 926-933

## 8. INTERNET REFERENCES

Virtual musical Instruments can be viewed at the Web Site of CIARM, Bologna office:

[HTTP://www.ciarm.ing.unibo.it](http://www.ciarm.ing.unibo.it)

More information about virtual reconstruction of Violins could be found at the following URL:

[HTTP://www.ciarm.ing.unibo.it/researches/violin-1.html](http://www.ciarm.ing.unibo.it/researches/violin-1.html)

Sound examples can be downloaded directly from the site:

[HTTP://www.swets.nl/jnmr/vol27\\_4.html](http://www.swets.nl/jnmr/vol27_4.html)

On the modification of sound quality due to obsolescence in flute, there are many informations at the address:

[HTTP://www.ciarm.ing.unibo.it/researches/flutes.html](http://www.ciarm.ing.unibo.it/researches/flutes.html)

Virtual reconstruction of sound quality of trumpet, with sound examples, is available at:

[HTTP://www.ciarm.ing.unibo.it/researches/trumpet/](http://www.ciarm.ing.unibo.it/researches/trumpet/)



# LASER SCANNING TECHNOLOGIES FOR 2D AND 3D IMAGING AND CHARACTERIZATION OF DECORATED MONUMENTAL SURFACES

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## Abstract

Laser scanning prototypes, formerly developed in active remote sensing systems and in remote vision and metrology devices based on the amplitude modulation technique, have been specialized for high resolution multispectral applications suitable to be used in the characterization of large surfaces relevant to monumental Cultural Heritage.

A three colour imaging topologic radar (RGB-ITR) has been developed for high resolution 3D imaging of frescos and successfully utilized in chapels of churches dating back to the Renaissance period. The high resolution 3D models reconstructed have allowed the hyper-realistic rendering of coloured features and the identification of surface irregularities, either in the layers or in the thickness of the underlying plaster, possibly related to otherwise undetectable damages.

A laser induced fluorescence scanning system, capable of 2D monochromatic images acquisition on up to 90 different spectral channels in the visible/UV range has been developed and utilized in field campaigns in order to investigate the presence and the aging of consolidants as well as the occurrence of bio degradation. Its utilization in combination with the RGB-ITR on the same field campaign is reported. A new prototype with a line scanner facility for high speed data acquisition has been recently realized and is currently under laboratory tests.

Different methods for image classification are presented, examining the possibilities offered for data fusion from different active and passive sensors, based on both optical and acoustical techniques. Two methods have been selected for LIF data processing software, one based on spectral angle mapper and the other one on principal component analysis. Both methods have been implemented to extract the information relevant to conservation strategy and visualize damaged areas in suitable false colour combinations of the collected images.

Eventually, an augmented reality system with the possibility of projecting the image reconstruction on the real target has been realized as a tool for accurate surface study and for better fruition.

Results on data collected in preliminary laboratory investigations on reference materials and during a recent field campaign on frescos and are reported and discussed.

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**Keywords:** laser scanners, 3D model reconstruction, hyperspectral images, laser induced fluorescence (LIF), augmented reality

## 1. - Introduction

Non invasive optical diagnostics are of special interest for application to Cultural Heritage. Laser based devices, coupling the possibility of remote application up to several hundred meters with image capabilities, coming either from precise scanning systems or multichannel detectors, have recently increased this interest.

Laser radar, based of elastic backscattering from the target, can be utilized to remotely get accurate information about the target shape and reflectance. Remote vision and metrology devices based on the amplitude modulation technique (imaging topologic radar) belong to this category. After development for industrial applications, these instruments have been specialized for high resolution multispectral applications suitable to be used in the characterization of large surfaces relevant to monumental Cultural Heritage.

A three colour imaging topologic radar has been developed for high resolution 3D imaging of frescos and successfully utilized in chapels of churches dating back to the Renaissance period. The high resolution (sub millimetric) 3D models reconstructed allowed for hyper-realistic rendering of coloured features and for identification of surface irregularities, either in the colour layers or in the thickness of the underlying plaster, possibly related to otherwise undetectable damages (scratches, detachments, etc).

Laser scanning prototypes have been already developed in active remote sensing systems for environmental applications, such as the fluorosensor lidar for oil spill detection at the marine surface [1]. These instruments, detecting wavelength resolved the radiation anelastically scattered from the target, are able to identify surface species by means of their characteristic spectral signatures (namely fluorescence) after a selective UV laser excitation. A LIF (laser induced fluorescence) scanning system, capable of 2D monochromatic images acquisition on up to 90 different spectral channels in the visible/UV range has been developed and utilized on field campaigns in order to investigate the presence and the aging of consolidants as well as the occurrence of bio degradation [2]. A

new prototype with a line scanner facility for high speed data acquisition has been realized and is currently under laboratory tests.

Several methods for image classification are known, the most common are presented here while examining the possibilities offered for data fusion from different active and passive sensors based on both optical and acoustical techniques. In particular two methods have been selected for LIF data processing software, one based on SAM (spectral angle mapper) and the other on PCA (principal component analysis). SAM algorithm has been implemented to extract the information relevant to the presence of a specific component (whose spectrum is contained in our data base) at the imaged surface, while the PCA is a statistical tool allowing for a blind identification of most important spectral component in an image, thus increasing the chances to best visualize damaged areas in suitable false colour combinations. Joint operation of the LIF scanner and the RGB-ITR in field campaigns already resulted to the advantageous to the restorers [3]; a further example is given here after treating LIF images with the PCA algorithm.

An augmented reality system with the possibility of projecting the image reconstruction on the real target has been realized as a tool for accurate surface study and for better fruition.

Results on data collected during Hrastovlje campaign on frescos and in preliminary laboratory investigations on reference materials are reported and discussed. Some conclusions are presented at the end, highlighting further work needed to increase the applicability of these systems to Cultural Heritage monumental surfaces characterization and preservation.

## **2 Experimental apparatus, laboratory results and data processing**

### **2.1 Image Topologic Radars**

Imaging Topological Radars (ITRs) are a class of 3D laser scanners that exploits the amplitude modulation range finding technique for the determination of distance. This technique enables the simultaneous recording of both range and reflectivity data, a feature that makes ITRs especially suited to Cultural Heritage applications, particularly for the realization of accurate and realistic 3D models of delicate artworks of both small (~1 m) and intermediate or large scale (up to ~30 m).

#### **2.1.1 Monochromatic ITR**

ITR systems [G. Fornetti, L. Bartolini, M. Ferri de Collibus “Multispeckle topologic radar system equipped with a coherent light beam transport and unimodal propagation elements, relevant to metrology and vision applications” Italian patent RM 2003 A000588 deposited on 22.12.2003] belong to the category of amplitude-modulated (AM) laser rangefinders. Range information is obtained by determining the round trip time delay of an AM sounding beam via the measurement of the phase delay  $\Delta\phi$  of the signal photocurrent with respect to a reference signal. For each sampled point, the distance  $d$  between the scanning mirror and the target is given by the formula:

$$d = \frac{c}{n} \frac{\Delta\phi}{4\pi\nu_m} \quad (1)$$

where  $\nu_m$  is the modulation frequency,  $c$  the velocity of light in vacuum and  $n$  the refraction index of the transmitting medium. For laser optical powers such that the signal shot-noise dominates over all other noise sources in the detection process, the accuracy of measurements can be showed to increase with the modulation frequency  $\nu_m$ . Due to the cyclic nature of the modulation process, the AM range finding method is generally affected by the so-called “folding” ambiguity. Univocal distance measurements are only possible within a well-determined range window, equal to half the value of the corresponding modulation wavelength  $\lambda_m$ . In order to overcome this limitation which would confine high resolution to short distances, two modulation frequencies are simultaneously used. Provided the low-frequency range window is chosen large enough to encompass the whole scene of interest, unambiguous yet less accurate low-frequency measurements can be used to remove the ambiguity that affects the corresponding high-frequency, more accurate, measurements. This technique enables to measure distances at the level of accuracy permitted by the high-frequency mode but well beyond its intrinsic range and can profitably be used to obtain accurate digitisations of large scenes, such as building facades or interiors, vaults etc.

ITR systems are designed to have a passive optical head - mainly constituted by mirrors and lenses - separated by the active opto-electronic system, which includes the laser source and the detector with dedicated electronics. Unlike laser scanners based on optical triangulation, in ITR systems the launching optics is coaxial with the receiving optics in a strictly monostatic configuration. This feature enables to avoid self-occlusions during the scanning process and eliminate off-axis optical aberrations, resulting in an improvement in lateral resolution.

The active and passive subsystems are optically coupled through optimized optical fibre connections. This modular setup enables to place the passive module in the position that is more convenient for the measurement, without compromising the overall functioning of the system even in extreme or hostile conditions, such as at high or low temperature or in presence of intense ionizing radiation background. Monochromatic ITRs, using a single laser source in the NIR region of the electromagnetic spectrum, have been utilised in several field campaigns both in Italy (palaeochristian church of S. Maria Antiqua in Rome, Etruscan tomb of the Blue Demons in Tarquinia) and abroad (Sucevița Monastery in Romania) [3].

### 2.1.2 RGB-ITR – the form and the colour

Profiting of the experience maturated over a decade with monochromatic ITRs, at ENEA CR Frascati the RGB-ITR has been recently realized and patented [G. Fornetti, L. Bartolini, M. Ferri de Collibus “Threedimensional Radar optical method and device based on three modulated RGB diode lasers for metrological and art work applications” Italian patent RM2006A000651 deposited on 6.12.2006]. RGB-ITR is a colour 3D laser scanner, which enables the simultaneous recording of both range and colour, in the form of RGB triplets. This is the first AM 3D scanner ever realised that can natively acquire colour information.

The system uses three laser sources at optical wavelengths of 450 nm (blue), 532 nm (green) and 650 nm (red) respectively, combined into a single ray by means of a dichroic optical component. A motorized mirror is used to focus and sweep the beam onto the target, and the collected backscattered signal is then split again into the three original red, green and blue components by means of an optical demultiplexer.

Each colour return signal is separately detected by a low-noise avalanche photodiode detector, and analyzed by means of a lock-in amplifier unit, also used to modulate the correspondent beam component. Typical modulation frequencies are 190 MHz for red, 1-10 MHz for blue and 25 kHz for green. The three colour channels are converted in standard RGB form by using the Grassmann law - which states the linearity of chromatic response in human colour perception - with coefficients corresponding to the optical frequencies of the laser sources used. The RGB triplets are then subject to a calibration procedure that enables to fix the white point in colour space by means of data preliminarily acquired on a white certified diffusive target. Specifically developed, copyrighted software applications are finally used to process range and calibrated RGB data and generate faithful, highly realistic 3D digital models. The resulting models can be further post-processed and exported into the most common 3D file formats.

The portable system is shown in **Fig. 1**, as settled during the field campaign at Hrastovlje church (see sect. 3.1); its characteristics are summarized in **Table I**.



**Fig. 1** – The RGB-ITR prototype during field operation. Front: optical head and fibre glass connections; Rear: laser and detector, control electronics.

**Table I** – Characteristics of the RGB-ITR system as assembled during Hrastovlje campaign (\* due to a compromise with the time available for scanning, a resolution 4 times bigger than the actual ITR resolution was settled).

Scanning system type	Polar
Wavelength laser sources (red, green, blue)	700 nm, 530 nm, 460 nm
Modulation frequency (high, low precision)	190 MHz, 10 MHz
Spot size at 3.5-5m	0.8-1.2 mm
Lateral resolution at 3.5-5m (x, y)	1mm, 1mm*
Error distance measurement at 3.5-5m (z)	0.2-0.3 mm
Acquisition time per point	10 ms
Acquisition time for a 1800x1800 image	9 hours

### 2.2 LIF scanners

It is well known that fluorescence signatures of materials are of interest in Cultural Heritage surface characterization. Provided that a sufficiently low intensity beam is focussed onto the examined surface to avoid the occurrence of photobleaching, laser induced fluorescence (LIF) can be considered a non destructive surface investigation technique, with interesting possibilities for remote application. By coupling the use of a laser source with suitable scanning devices fluorescence images can be collected as well. Apart from the optical scanner quality, which determines the geometrical parameters, performances relevant to specific applications are based on the spectral signature characteristic for each chemical compound laying on the examined surface. The detection of the emitted fluorescence radiation allows the identification of the different materials utilized, which is needed in view of a planned restoration. In fact it reveals with high space resolution the occurrence of retouches, traces of former restorations and consolidants not otherwise reported in the documentation relevant to the artwork, and to identify extraneous materials onto the surface such as degraded substances from pigment or consolidants, air pollutants, waxes, microalgae and fungi responsible for biological attack. The construction of relevant data bases containing the fluorescence signatures at different laser excitation wavelengths (266 nm and 355 nm) is currently in progress in our laboratory.



### 2.2.1 The point scanner

The hyperspectral scanning LIF system here used to collect data during the field campaign (sect. 3.2) is based on a previous instrument's version with a point scanner [4] successively patented [F. Colao, R. Fantoni, L. Fiorani, A. Palucci "Fluorescence scanning electro-optical device for outdoor applications to Cultural Heritage" Italian patent RM2007A000279 deposited on 21/5/2007]. All the mechanical and optical elements are installed in an aluminium box of  $58 \times 43 \times 36 \text{ cm}^3$ , for less than 15kg. Its small size and light weight allow an easy transport of the system and its operation from scaffoldings, in the case of surfaces out of the current maximum range for remote operation (10 m). A diode pulsed Nd:YAG laser (Thomson DIVA) is used as light source to generate radiation at 266 or 355 nm, producing laser pulses of 10ns duration at fluence of 1 to  $50 \text{ mJ/cm}^2$ . A linear array (Ocean&Optics) is used as spectrometer; its entrance is protected from the intense backscattered radiation by means of an appropriate dichroic filter. Since no optical elements are used to collimate the laser beam the overall spatial resolution is a function of the operation distance and in the present case on the field we had a resolution of approximately 1 to 2mm from the spot size on the target at about 5 m distance. The digitized spectrum collected at each scanned point is transferred to a portable computer where a LabView program allows the user to set experimental parameters, control data acquisition, and perform a preliminary data analysis. As a result up to 90 different monochromatic images (collected from 280 to 800 nm in adjacent steps with 10 nm resolution) are collected from the scanned area. Unfortunately, hyperspectral image collection by a point scanner is a time consuming operation: typically  $1 \text{ m}^2$  of surface could be scanned in 8 hours at 1mm lateral resolution.



**Fig. 2** – Compact LIF line scanning, the vertical wheel is mounted on a tripod, vertical scanning is performed by means of an accurate stepping motor on the back side of the wheel. Transmitting and receiving optics are in the front, the ICCD and the laser on the rear.

**Table II** - LIF line scanner performances (\* corresponding to a line of 1.5 m length at a 25 m distance).

Horizontal resolution	640 pixel
Angular resolution	0.1 mrad
minimum acquisition time per line	200ms
FOV aperture	3°

### 2.2.2 The line scanner

Our former LIF scanning system, capable to collect hyperspectral fluorescence images scanning a surface point by point with 1 mm resolution, has been upgraded for applications to large Cultural Heritage surfaces (e.g. frescos, decorated facades etc). A new compact set up has been built aimed to increase performances in terms of space resolution, time resolved capabilities and data acquisition speed. Major achievements have been reached completely changing the optical approach and consequently the detector utilized:

- in the scanning the step to step point focalization has been changed into line focalization by using a quartz cylindrical lens and an imaging spectrograph (Jobin-Yvone CP240);
- the linear array detector, responsible for the multichannel spectral resolution, has been replaced with a square ICCD sensor (ANDOR iStar DH734, pixel size  $13 \mu\text{m}$ ), mounted behind a slit parallel to the laser line footprint during scanning.

This arrangement is characterized by having the spatial and spectral information on two mutually orthogonal directions imaged on the detector, with submillimetric spatial resolution and 5 nm spectral resolution. Additionally, it is possible to implement time resolution measurements on the nanosecond scale by controlling the electronic gate of such a detector, collecting time resolved images delayed with respect to the excitation laser pulse.

The overall current system performances are summarized in **Table II**. With the new optical system based on the use of cylindrical lens an image of  $1.5 \times 5 \text{ m}^2$  is currently scanned in less than 2 minute at 25 m. The compact arrangement is shown in **Fig. 2**, the same diode pumped Nd:YAG laser source has been utilized in combination with III and IV harmonics crystals to generate the UV radiation.



Preliminary laboratory experiments have been already performed in laboratory collecting passive images and LIF signals from different standards (white and black paper, dye loaded plastics), and have shown the capability of remote material identification by means of the available data processing software (see sect. 2.2.4) on raw hyperspectral images. Prior to field utilization additional work is in progress to correct image intensities taking into account the optical collection efficiency at different angles.

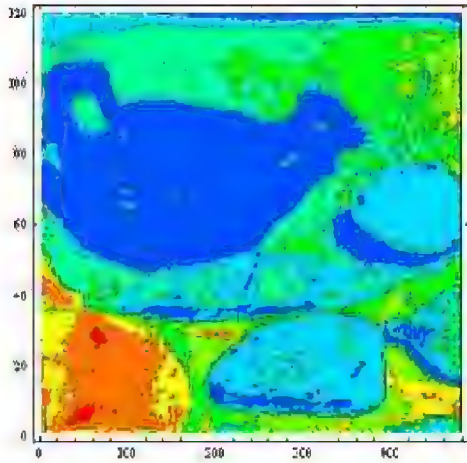
### 2.2.3 Image processing

As classification we mean the operation to assign an object to a pre determinate group, generally fixed [5]. To this aim the object must be characterised by a measurable set defining a multidimensional *features vector*. An automatic classification system is composed by a first part where the characteristics are translated and extracted; in a second part the classification algorithm assigns the membership degree of a class [6].

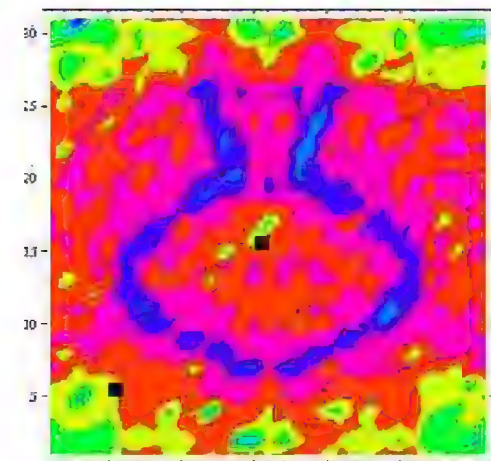
Most used methods are based on the time analysis, (i.e. integral and differential estimator), on the mapping in frequency domain based on a metric, (i.e. Spectral Angle Mapper Classification (SAM), Spectral Correlation Mapper (SCM)), on multivariate statistic analysis (i.e. Principal Component Analysis (PCA), Support Vector Machine (SVM)) and on omomorphic transformations that preserve the defined operations (CEPSTRUM which is the anagram of the word spectrum).

In the following we are focussing our attention only for the first family of methods and SVM. As example in **Fig. 3** we have a set of archaeological samples separated by the Centre of Gravity (CG) method. In this case for the assignment we need a reference database.

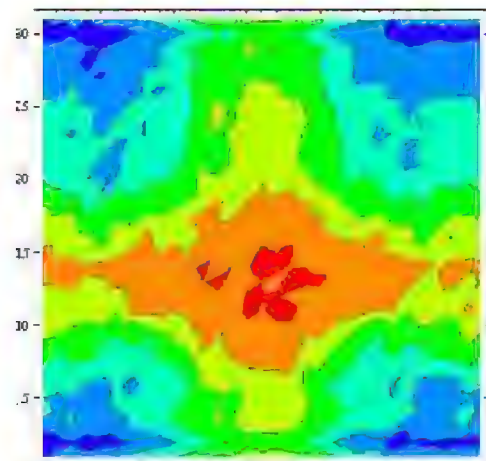
In **Fig 4** (left) we select two areas of a sonar picture of an amphora and were looking for similar pixels. In this case the analysis did not need the use of a reference database. In **Fig. 4** (right) we show the result of the internal/external volume identification on the same target performed by SVM.



**Fig. 3** – CG identification of the materials in an underwater image of archaeological goods by visible spectra. Colours after classification correspond to different surface biolayers.



**Fig.4 (left)** - Selection of the signal to classify an amphora. We selected two kinds of spectra (black squares) and looked for similarity.



**Fig. 4 (right)** - Result of classification by SVM and identification of external/internal volume.

### 2.2.4 Features characterization algorithms developed on reference samples.

Two methods have been selected for LIF data processing software: SAM and PCA.

We used the Spectral Angle Mapper (SAM) algorithm for LIF image analysis [7]. According to SAM given a reference spectrum and a pixel in the scanned areas, we have to consider the spectral channel intensities as the

coordinate components of two vectors in a multidimensional space. Since any two vectors generate a hyper plane and two directions over it, the SAM algorithm computes a spectral angle between the pixel spectrum and a reference spectrum: the smaller is the angle more similar will be pixel and reference spectra. The method takes the arccosine of the dot product between the test spectrum  $u$  and the reference spectrum  $w$  with the following equation:

$$\alpha = \cos^{-1}(\hat{u} \cdot \hat{w}) = \frac{\sum_{i=1}^N u_i w_i}{\sqrt{\sum_{i=1}^N u_i^2 \sum_{i=1}^N w_i^2}} \quad (2)$$

Our laboratory data base of consolidants has been utilized to test SAM capabilities of their identification on fresco surfaces, painted with different pigments, at two different UV wavelengths [7].

Principal Component Analysis (PCA) is a technique which reduces the dimensionality of data, transforming the original variables into new uncorrelated ones (principal components or factors, PC), which are linear combinations of the original data and confine the greatest proportion of the total variance, according to the following algorithm:

$$x_{ik} = \bar{x}_k + \sum_{\ell=1}^N p_{\ell k} t_{i\ell} + e_{ik} \quad (3)$$

This statistic tool has been implemented in order to have the possibility of automatic handling of multispectral images. We used the entire spectra as input data, organized in a matrix containing the intensities at the different wavelengths in columns and the spectra in lines. The method has been tested on consolidants [8]: in this case our dataset had 3600 lines and 120 columns and succeeded in their identification by the first 3 components upon excitation at 266nm. Once PCA is run, the most important components (usually the first three) can be utilized for false colour image reconstruction, stressing the information content peculiar to the image, for instance the dominance of a specific colour or a kind of consolidant coating not uniformly present. Note that PCs are not necessarily (and in most cases not even eventually) associable to a specific spectral feature for a single constituent, so they do not permit to identify the anomaly at the surface, but only to reveal its presence.

### 2.3 Augmented Reality in the Cultural Heritage context

Augmented Reality (AR) [9] is a recent technology under development in the most advanced laboratories. It deals with computer based systems that display synthetic information to a user in such a way that the data appear merged to the objects in the real world surrounding him. In Cultural Heritage context, AR can be a promotion tool for didactic or tourist fruition, but it is expected as a powerful aid especially for a restoration operator, allowing the exploitation of all kind of geometrical mapped data, such as material characterization, damage diagnosis, restoration history, planned restoration actions.

A “see through” configuration for AR systems includes optical see-through Head Mounted Display (HMD), i.e. a portable display placed in front of the eyes of the user with a degree of transparency that allow to see the real world around him with no significant distortions or colour modifications. In this way the image from the real world is received by the retina directly using the light incoming from behind the HMD screens. In between the user and the real world, the device places the augmented information by optical semitransparent mirror that superimpose to the real world the light coming from little monitors embedded in the HMD.

Another key component used in many AR realisation systems is the “tracking device” that helps the system to identify the scene of the real world watched by the user, in order to properly place the relevant synthetic information. Knowing the user position and orientation, it is possible to dynamically update accordingly the augmented data over the scene. The whole process is generally known as registration task. To accomplish the tracking function, different kind of hardware sensing devices exist, each suitable for specific application context, according to requirements in accuracy and speed and also to environment characteristics such as physical accessibility, wideness etc. Of course, the algorithmic solution, necessary for elaborate the sensing data to realize the pose estimation, varies too.

#### 2.3.1 A tool for AR fruition of LIF data

We realized a prototypal operator assistant for work of art restoration. It's an AR development suitable for room-wise wide working environment. Apart from the algorithm developments, the hardware system consists of a Main Host (MH), a video camera, a monitor and an optical see-through HMD. The system intelligence performs three main tasks: the tracking of user head in the work environment, the interactive manipulation of the augmented contents, and the correct presentation of the virtual information. This must be blended with the real scene, in order to avoid hiding any useful information. This is realised by the HMD where we present all the information needed for the assisted operations, while the service monitor shows other kind of information.

The video camera placed on the user head constitutes the tracking device. Each acquired frame is processed by computer vision techniques to estimate the relative pose between the video camera and a particular fiducial sign pre-disposed on the objects where we want to see the augmented data on. That fiducial signs are well known pictorial

markers whose geometry and pattern are fixed in set up stage. To carry out correctly the pose estimation, we have to know the prospective projection and optical aberration under which the world is seen by the objective of the video camera, this requirement is fulfilled in a calibration step previous to the working time.

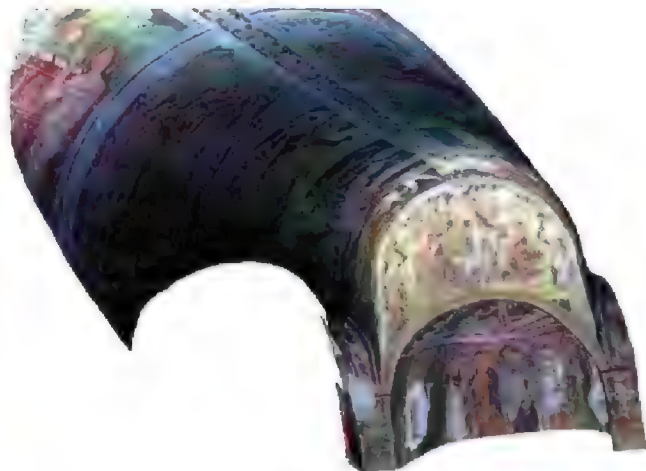
The major weakness of computer vision relied solutions is due to the occlusion problem, which arise when the markers go out of camera field or it is covered by something (i.e. the user arm). To partially overcome this problem, it is necessary to use more markers on the same scene. **Fig. 5** shows what the user see through the HMD: a 3D elaboration of LIF data acquired on the square portion is blended on the real Byzantine icon.

### **3 Results of a field campaign: Hrastovlje church**

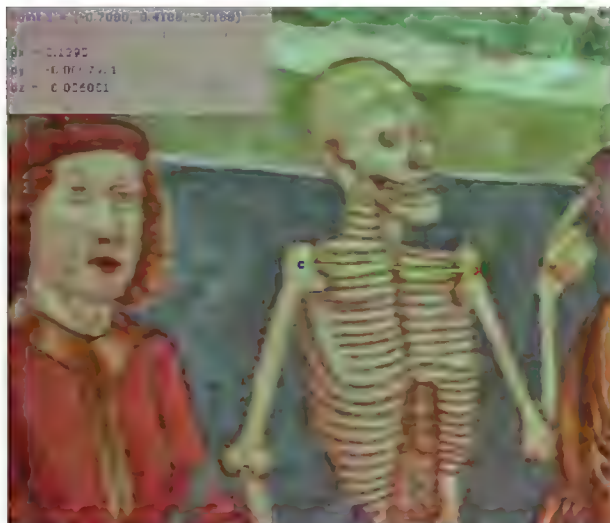
The ENEA RGB-ITR and LIF scanning systems were applied to frescos analysis in the Romanesque church of the Holy Trinity in Hrastovlje, a small village of Slovenia. The interior walls are completely covered with the frescoes of 1490, but the church suffered many restorations in the past; the frescos remained hidden for a long time and have been rediscovered on 1949 under a thick layer of lime. Frescos show scenes from the Old and New Testament.



**Fig. 5** - LIF data projection on the image of a real icon, as seen by the operator through his HMD.



**Fig. 6** – 3D model of the apse and vault of the Holy Trinity Church Hrastovlje



**Fig. 7** – Virtual metrology on a section of the 3D model of the Macabre Dance fresco.



**Fig. 8** - Accurate profilometry on the 3D model of the painted apse





**Fig. 9** – 3D model of the entire wall with the Macabre Dance fresco. In the middle the model is overlapped with a 2D LIF image (PCA reconstruction in false colours), showing effects of discolouration and retouches.

### 3.1 RGB-ITR models

The RGB-ITR has been utilised in a 3D digitisation campaign, carried out in Hrastovlje (Slovenia, 2007) upon invitation of the Institute for the Protection of Cultural Heritage of Slovenia. An accurate, colour 3D model of the interiors of the Romanic Holy Trinity church was realised, to be used for monitoring, restoration and cataloguing purposes. The 3D model of the apse, representing the Throne of Grace, and of the entire church vault is shown in **Fig. 6**. The model of the famous wall where the “Macabre Dance” is represented has also been acquired.

About 60% of the church's surface was 3D digitized in 5 days by means of the RGB-ITR, for a total of 11 scans and almost 90 data recording hours. During the campaign, the RGB-ITR instrument fully demonstrated its capability for metrology and structure profiling. In **Fig. 7** we can see a virtual meter overlapped on the 3D model: with this instrument, it is possible to investigate all real distances (in meters), between the blue and red points marked. In **Fig. 8** we can see the profile obtained by the intersection of a virtual plane and the 3D model. The virtual plane can be moved freely in the virtual environment so to obtain virtually endless contours of the investigated object. This instrument is very powerful for the remote diagnosis of the model structure: in fact, by the analysis of the profile, we can highlight possible fissures or deformations which can corrupt the stability of the monument.

Furthermore, the software tool developed for handling 3D models allows building a sort of hyper-texture to overlap the 3D model: each layer of this hyper-texture contains spatially-referenced information, obtained by the different instruments, for a multi-diagnosis of the investigated monument. An example of data collected during Hrastovlje campaign is shown in **Fig. 9**, where the false colour reconstructed LIF image is overlapped on the 3D model independently collected.

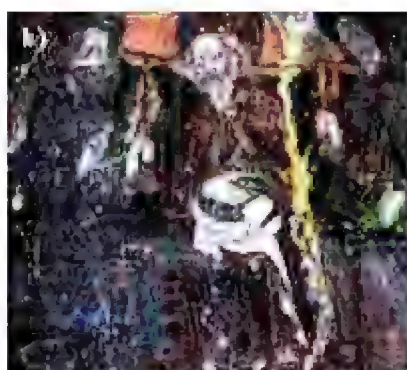
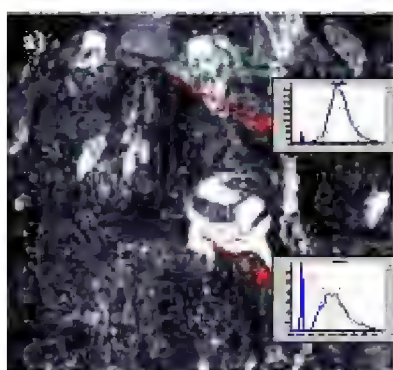
### 3.2 LIF images

The LIF system provides information on the present conservation status, identifies areas with biological attacks and gives details on the restoration methods of the frescoes under study.

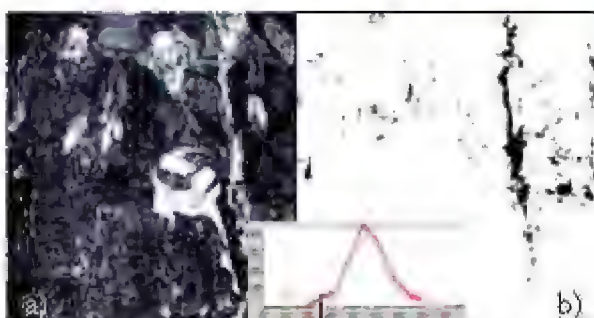
In every scanned image the light emitted by each pixel is decomposed in its components, providing the maximum extent of spectral information today conceivable in the UV to VIS wavelength range (200 – 800nm). 2D monochromatic images are reconstructed at each detected wavelength. In **Fig. 10a** the fluorescence image at 470 nm of the detail of a fresco, obtained with the laser excitation wavelength at 355 nm, is shown, with the fluorescence spectra by different pixel corresponding to different area on the fresco. A line along a crack in the wall appears in the RGB image reconstructed by the CG method in **Fig. 10b**, which gives evidence of deterioration, depigmentation and paint retouches. SAM analysis has been applied to these images (**Fig. 11**). After identifying the reference spectrum on the retouched scratch, it has been possible to find out traces of other retouches made with the same material.

A clear evidence of the crack area is also obtained by PCA once reconstructing the image by using the first three principal components, as shown in **Fig. 12**. The comparison of **Fig. 12** with **Fig. 11**, on one hand, stresses the power of the statistical analysis (PCA) which is able to recognize blindly the presence of an anomaly, on the other hand demonstrates the superiority of SAM, once a reference spectrum is available, since it allows the identification of the origin of the anomaly from its spectral signature (repainted plaster).

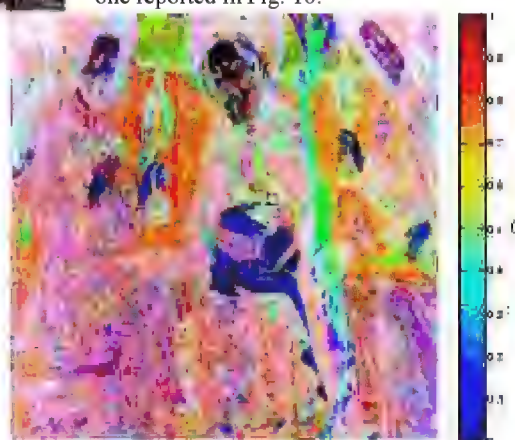




**Fig. 10** - Images by LIF scanning of the detail of a fresco in the church of the Holy Trinity in Hrastovlje a) Fluorescence image by LIF system at 470 nm, b) the corresponding false colour image.



**Fig. 11** - SAM image analysis of the detail of a fresco in the church of the Holy Trinity in Hrastovlje. By considering as reference spectrum, in red, the fluorescence spectrum emitted from the crack area in a), SAM provides a map of pixel with high spectral similarity as in b).



**Fig. 12** - PCA RGB reconstruction from 90 LIF monochromatic images as the one reported in Fig. 10.

#### 4 Conclusions

Two prototypes of laser scanning systems for painted surface diagnostics have been realized and successfully demonstrated in a field campaign on the frescos of a renaissance church in Slovenia.

Accurate 3D models have been built containing both the metrology data and three colour images of the scanned surfaces. Results of hyperspectral LIF scanning, after image processing, have gave additional information on surface degradation and retouches not evident from the surface reflectance at the investigated visible wavelength.

Work is in progress to utilize the augmented reality tool on data collected during the Hrastovlje campaign, in order to supply the restorer a powerful method to exactly locate damages visualized with either of the laser based remote imaging diagnostics.

#### Acknowledgements

Prof. M. Strlic is gratefully acknowledged for the invitation in Hrastovlje and partial supporting to the campaign together with the Italian Ministry of Foreign affairs (bilateral Italian-Slovenian agreement for years 2007-2008).

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# THE ACOUSTICAL SURVIVAL OF ANCIENT ROOMS THOROUGH TWO MILLENIA

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## Abstract

The musical heritage of Western Europe, which has its beginnings in the Roman Empire, covers almost twenty centuries of history. Nevertheless, after the fall of Rome and the establishment of Ostrogothic rule in Ravenna in 493, and, subsequently, Byzantine rule from 540, only a few historic elements are available to describe musical features of that period. Only a very few spaces from the sixth century are still available. Among them, the churches of S. Sofia in Constantinople (later transformed into a mosque) and the Basilica of S. Vitale in Ravenna, were the main representative buildings of that time.

In order to properly evaluate the sound effect of the dome, acoustic measurements in the church were performed, obtaining binaural and B-format IRs. Moreover, a dry chant of the original Ravennate versus (namely *Lux de luce Deus tenebris illuxit Avernī*) was recorded in the large anechoic room at ISVR, Southampton, UK. Finally, some listening experiments were conducted in the listening room at University of Bologna, virtually reproducing sound effects in the church by means of 3D Auralisation.

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## INTRODUCTION

The church of San Vitale invites a person to circulate through areas partially visibly obscured by columns, partially open to vistas of inner, almost tangible volumes of space. These characteristics make the acoustics of the church very sensitive to the position of sound sources and receivers. Moreover, in the sixth century, Ravennate choral music was considerably different from the Gregorian music of later centuries, and sound effects produced in the church were remarkable. The proper understanding of sound perception of choral music in the church could be retrieved considering the acoustics of the room and reproducing its effects in the “Arlecchino” listening room by means of 3D Auralisation (Ambisonics and Stereo Dipole).

In this paper the main acoustical parameters calculated from the measured impulse responses are analysed and reported. Besides, some auralisation experiments are presented.

## HISTORICAL BACKGROUND

The construction of San Vitale at Ravenna was initiated by Bishop Ecclesius (526-534) and privately financed by the banker Julianus Argentarius in 526, while King Theoderic (493-526) was still living. It is an important example of the cultural exchange between East and West. The church was most likely consecrated on the first Sunday after Easter (Quasimodo Sunday), April 19, 548 by Archbishop Maximianus (546-556) when Ravenna had already been under Byzantine rule for eight years.



Figure 1: Images of San Vitale, Ravenna

Architecturally San Vitale has an octagonal double-shelled central plan with a three-story vaulted octagonal domed core surrounded on the lower two levels by an ambulatory and gallery (*matroneum*). The interior volume of the church is approximately 25800m<sup>3</sup>. Its design is influenced both by contemporary examples of churches and baptisteries in the eastern Empire, southern Gaul and northern Italy (Figure 1). Entry is via an outdoor courtyard (*atrium*) and adjoining elongated rectangular apse-ended porch (*narthex*). The extant interior wall mosaics of the

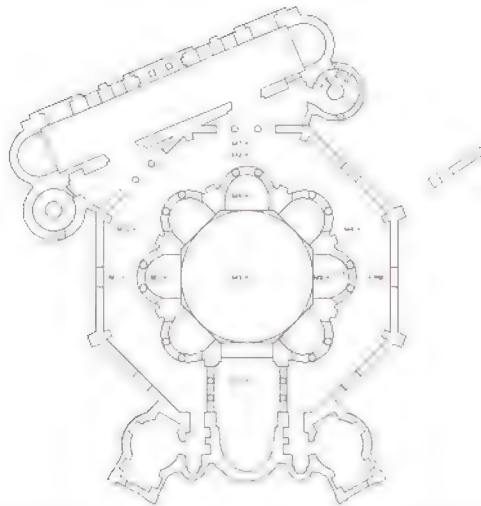


chancel apse are world famous and include vibrant representations of Biblical subjects and the processional imperial court of Justinian and Theodora (Figure 1).

From at least the sixth century to the liturgical reforms of Pope Gregory the Great (c.540-604), the Christians of Ravenna had their own rite and chant tradition suited for the churches of the city including San Vitale. One chant (*versus*) of the Ravennate rite in particular is appropriate for this church; *Lux de luce Deus tenebris illuxit Avern* (Levy 1971). While it is understood that liturgical practice had an impact upon sixth century church architecture very few available historical accounts describe contemporary musical features. Therefore an acoustic measurement campaign was carried out by means of binaural and 3D microphones and an omni-directional loudspeaker.

## MEASUREMENTS OF ACOUSTICAL QUALITY

The measurements of acoustical quality were performed by positioning the loudspeakers in the stage and microphones at several points throughout the church, as shown in Figure 2.



**Figure 2:** Positions of sound source and microphone placement within San Vitale.

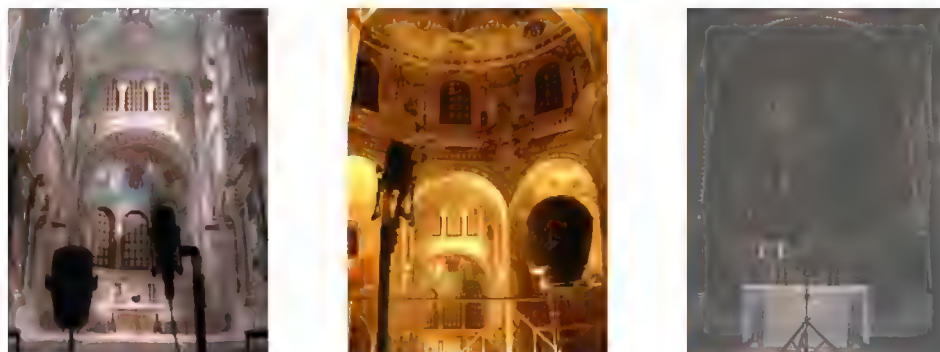
The acoustic measurement campaign utilised the following instruments:

- An equalised, omni-directional, loudspeaker located in the stage, located in three positions.
- A dummy head (Neumann).
- A Soundfield microphone (MK V) was added to the dummy head.

The measurements were conducted by means of a logarithmic sine sweep, ranging between 40 Hz to 20 kHz. The signals acquired by the microphones were stored in a 20bits 96 kHz sample rate soundboard (Layla), and then post processed in the laboratory.

## ANALYSIS OF MEASUREMENTS

The acoustical measurements were performed by positioning the sound source in 3 positions and the microphones at 10 positions within the church on the ground floor and balcony. Starting from IRs, the most important acoustical parameters (Clarity, T20, LF, IACC, STI, etc.) were calculated.



**Figure 3:** Images of the measurement instruments used within San Vitale



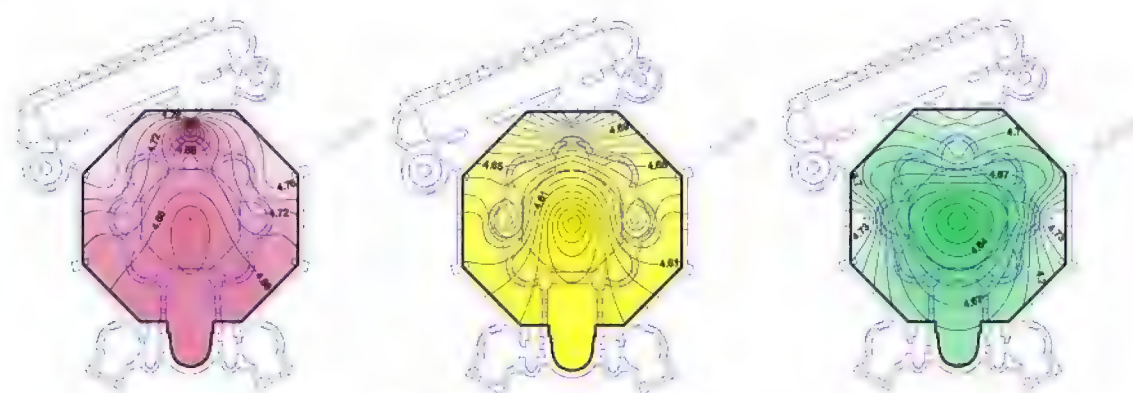
An example of Impulse Responses measured in the church interior is presented in Figure 4.



**Figure 4:** Acoustical measurements (WY, XZ and Binaural IRs) in San Vitale

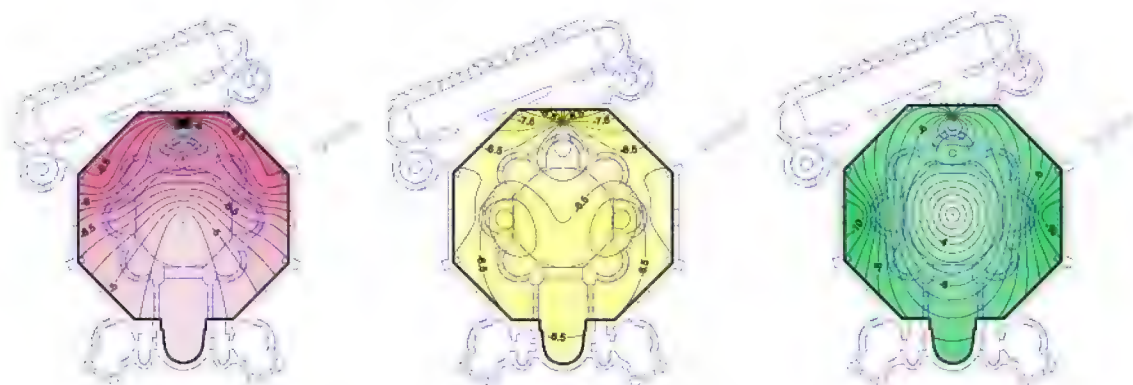
#### Spatial distribution of acoustical parameters

Acoustical parameters were mainly calculated from the W channel signal of Soundfield microphone, whilst IACC was calculated from the Neumann dummy head, and LF from the W and Y tracks of the Soundfield. Considering the values of acoustical parameters reported in Table 1, the resultant reverberation time was very long, San Vitale being a church this wasn't a completely unexpected discovery. Acoustical maps of reverberation time were calculated for every sound source. In Figure 5 the spatial distribution of T30 are reported:



**Figure 5:** Spatial distribution of T30.

Considering mono-aural acoustical parameters such as C50, CT and D, the measurements underlined the low intelligibility of the church. In Figure 6 the spatial distribution of C50 are reported.



**Figure 6:** Spatial distribution of clarity C50.

The reverberant tail caused low values of clarity, this being in general agreement with the typical properties of a place of worship.

#### Frequency distribution of acoustical parameters

The spatial acoustical maps of the parameters describe their distribution inside the church. On the other hand, frequency response could be evaluated by analysing the frequency domain in the acoustical parameters. The post process of all the impulse responses acquired is summarized in Table 1.

Freq. [Hz]	31.5	63	125	250	500	1000	2000	4000	8000	16000	A	Lin
Signal [dB]	31.31	63.57	68.73	71.04	75.05	77.60	80.64	81.96	75.15	67.56	86.59	86.71
C50 [dB]	-6.31	-8.96	-10.84	-11.12	-9.64	-10.28	-8.86	-6.05	-2.92	2.99	-7.10	-7.05
C80 [dB]	-4.45	-6.05	-8.68	-8.53	-7.50	-7.56	-6.33	-3.65	0.07	6.92	-4.71	-4.70
D50 [%]	20.04	14.17	9.07	8.82	11.82	10.21	13.64	21.45	35.96	64.82	18.36	18.67
Ts [ms]	232.46	371.80	409.25	438.61	434.60	403.21	325.71	214.56	114.77	63.20	278.20	287.95
EDT [s]	4.62	4.90	4.96	5.80	5.86	5.27	4.32	2.89	1.57	0.74	3.80	3.99
T20 [s]	5.53	5.59	5.17	5.58	5.74	5.27	4.39	2.91	1.69	0.74	4.46	4.75
T30 [s]	7.02	5.80	5.02	5.60	5.77	5.35	4.44	2.95	1.78	0.11	4.70	5.00
IACC	0.99	1.00	0.96	0.74	0.39	0.35	0.35	0.23	0.14	0.25	0.25	0.26
LE	0.54	1.12	1.21	0.84	0.82	0.89	0.70	0.68	0.50	0.25	0.66	0.65
LF	0.80	1.72	1.49	1.09	1.10	1.16	0.99	0.93	0.65	0.37	0.91	0.90
LFC	0.44	0.79	0.70	0.60	0.59	0.60	0.54	0.49	0.36	0.25	0.49	0.48

**Table 1:** Averaged parameters measured in San Vitale

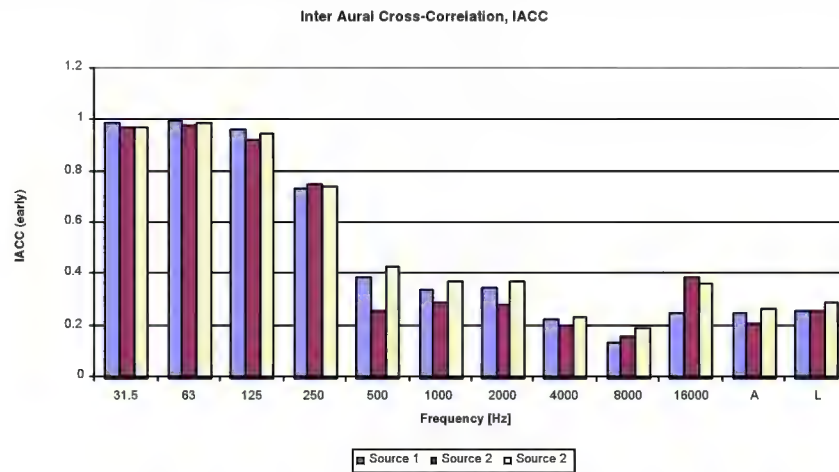
Two spatial acoustical parameters calculated were: IACC and LE. The Inter Aural Cross-Correlation coefficient (IACC) is defined as (1 and 2):

$$IACC = |\rho(\tau)_{\max}|, (\tau \leq 1ms) \quad (1)$$

where:

$$\rho(\tau) = \frac{\phi_{ds}(\tau)}{\sqrt{\phi_d^2(0) \cdot \phi_s^2(\tau)}} \quad (2)$$

In the following graph (Figure 8) the frequency values of IACC are reported for each sound source position.



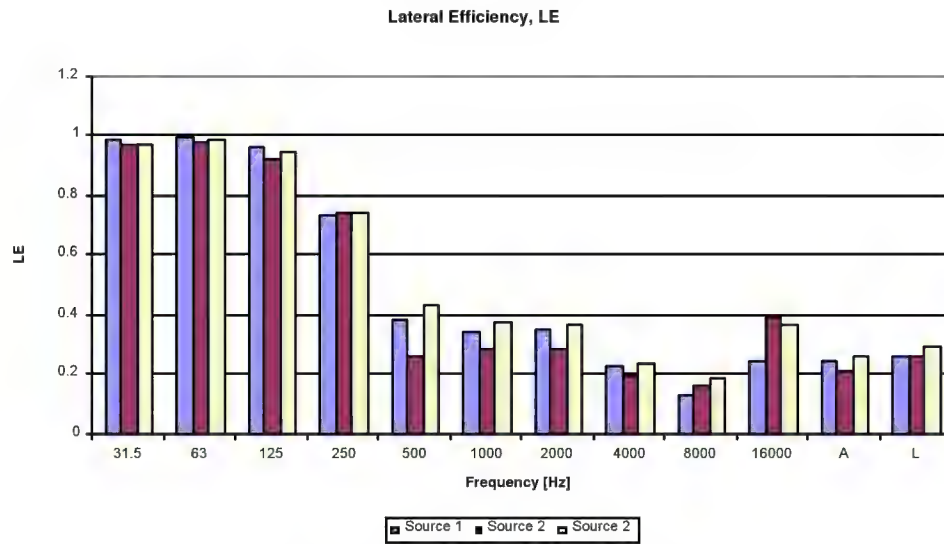
**Figure 7:** frequency distribution of IACC

## Lateral Efficiency, LE

Lateral Efficiency considers lateral acoustical energy perceived at a measurement position. The Lateral Efficiency (LE) is defined as (3):

$$LE = \frac{\int_{25\text{ ms}}^{80\text{ ms}} p_{\infty}^2(t) dt}{\int_0^{80\text{ ms}} p_0^2(t) dt} \quad (3)$$

The value  $p_{\infty}$  represents the impulse response obtained by means of a figure-of-eight microphone.



**Figure 8:** frequency distribution of LE

### ANECHOIC RECORDINGS

In order to virtually reproduce the acoustic characteristics of San Vitale in the Arlecchino listening room, a dry recording of the chant *Lux de luce Deus tenebris illuxit Averni* was required. Therefore a vocal recording in the large 90 Hz anechoic chamber at the Institute of Sound and Vibration (ISVR) at the University of Southampton, UK, was realized (Figure 10) by means of a mono-aural microphone (USB Samson CO3U).



**Figure 9:** Vocal recording at the ISVR. Southampton. UK

## CONCLUSION

The architecture of this beautiful sixth century church afforded special acoustical effects that invited the listeners to appreciate vocal music at several positions within its complex interior space. The aural elements of liturgical ritual were materially expressed and influenced the development of ecclesiastical architecture and, conversely, architectural innovations such as the centrally planned octagonal domed church and its acoustic properties may have influenced the development of vocal music. Nowadays the 3D auralisation is the only method of reproducing and restoring these Late Antique special effects.

In order to play back the music in the “Arlecchino” listening room, an acoustical measurement campaign in San Vitale was realized on April 30, 2006. In this work the acoustical properties of the church of San Vitale have been presented.

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## “TEXT POWER”: TOOLS FOR THE CULTURAL HERITAGE

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**Keywords:** information extraction, named entity recognition, text browsing

### 1. Introduction

This article presents NLP techniques (text mining, text analysis) to create tools for the evaluation, analysis and classification of text materials available on the web. In particular we developed tools for automatic extraction of linguistic relevant information related to the cultural heritage domain and tools for linguistic resources creation and exploitation. On this knowledge basis, we also developed a system for text browsing.

### 2. Cultural Heritage domain

The diffusion of internet and information technologies creates a continuous flows of information. Hence the role of the web is very important in the exploitation and promotion of the Italian cultural heritage.

There are several ways for promoting this field of interest: showcase websites with a rich and well-documented exposition of various cultural heritage objects, organized by geographical area, type of material or other specific criteria; online publications of detailed collections of artworks; indexing and browsing tools of available materials.

The risk is that an open philosophy, characterized by a strong interaction among users, causes problems of reliability in the contents production. In particular it is not enough to classify the information only with a hierarchical criteria but is more useful an approach based on criteria of semantic similarity.

Effective tools are needed for the structuring of as a system of knowledge, fitted out by appropriate linguistic resources. The aim of our approach is to create tools for the creation of a “knowledge network”, automatically extracted from text materials regarding the cultural heritage domain.

#### 2.1. Knowledge extraction

The aim of our approach is to create a network of knowledge, automatically extracted from cultural heritage written materials available online, which will allow the user to perform semantic syntheses useful for finding on the web new information sources better fitting their needs.

The automatic acquisition of texts is done through specialized crawlers.

The phases are typically:

- extraction of the relevant information from texts on the web;
- creation of linguistic resources;
- exploitation of linguistic resources extracted;
- text browsing.

### 3. Our experiences

Our research team, building upon experiences in the treatment of textual data [6]. Since, in our understanding, knowledge is expressed as relationships and dependencies among relevant information/concepts in the text, it can be extracted by means of statistical procedures.

Our new research can be summed up in two projects: *Linguistic Miner* [1],[2] and *Text Power* [3],[4],[5].

*Linguistic Miner* (LM) born from the consideration that the best source of linguistic information, at many different levels of analysis, is the language itself, represented by the largest possible collection of texts of the most different types (i.e. “language mine”). The project draws its importance from the integration of its various constituents: the wealth and extreme variety of textual data add value and significance to the next phases of analysis and exploitation of the mine.

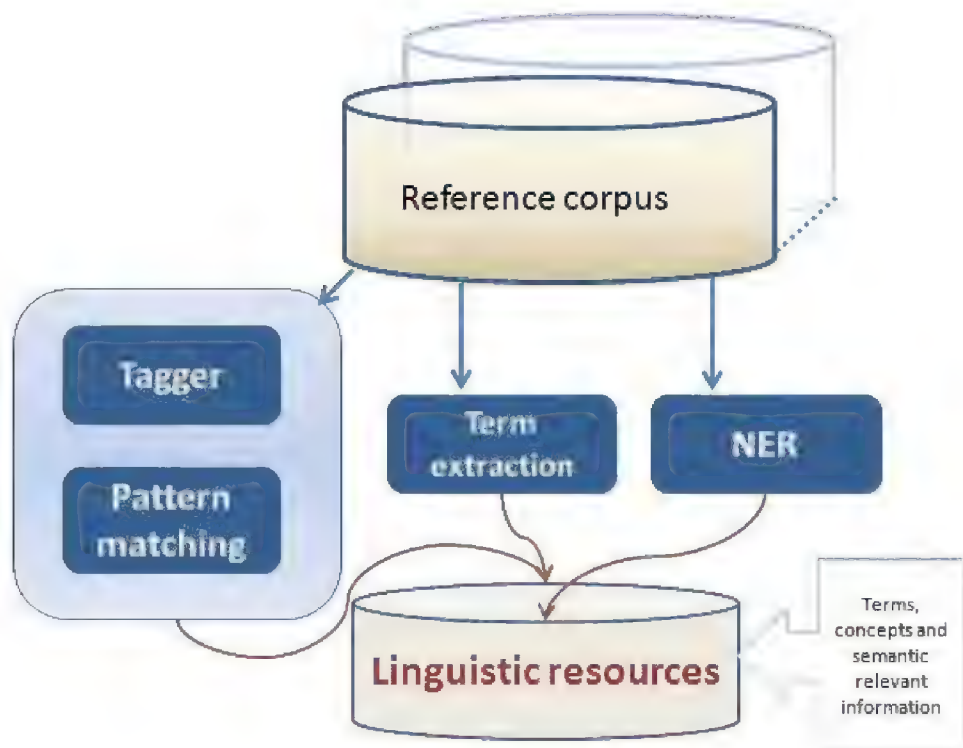
The main feature of the project is the building large language reference corpora, allowing for the creation and use of effective tools for the handling and processing, as well as the automatic linguistic synthesis, of such corpora.

LM evolved in *Text Power* (TP) project, which is aimed at the creation and exploitation of the linguistic knowledge. TP is specifically tailored for Italian language, but is open to other languages.

Our idea is that knowledge is expressed as dependency among relevant information and concepts in the text. On this basis, we developed tools for the analysis and synthesis of semantic-linguistic information and named entities. The relevant elements are typically: proper names, names of institutions, locations, and other relevant terms<sup>1</sup> for the specific domain. The key feature of this system is the ability to develop strategies for the classification and recognition of terms and named entities, very important prerequisite for a more efficient textual analysis: the more a text is “enriched” with annotated elements, the more a text can be well analyzed by tools for analysis, categorization, browsing and Information Retrieval.

### 3.1. Linguistic Resources

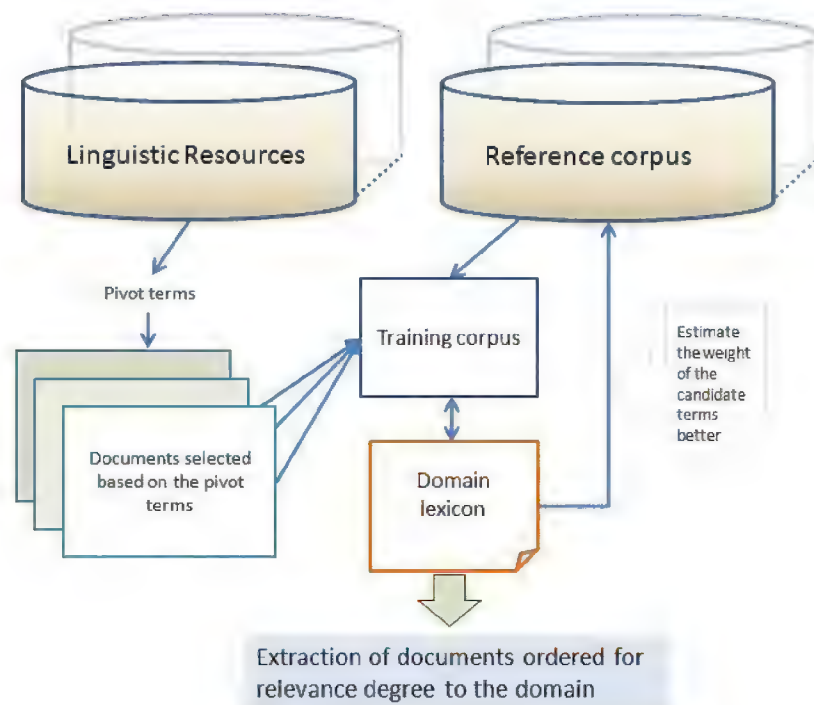
The first phase aims at extraction of documents from the web. The selection criterion is mainly geographical, but the methodology can also be extended to other text types and domain. On the basis of documents extracted by automatic spiders, automatic and specific parsers create the reference corpus for the cultural heritage domain. Relevant information and semantic concepts are then extracted from this corpus and constitute the linguistic resources of the specific domain.



**Fig. 1: Resource acquisition scheme**

The extracted linguistic resources can be summed up in:

- reference (text) corpus;
- repository of pertaining terms:
- named entities;
- single term;
- multi-words.
- domain lexicon for text categorization.



**Fig. 2: Domain lexicon creation**

### 3.2. Tools

The most important tools that we developed are:

- text analysis;
- text browsing;
- text categorization

A typical text mining task includes text categorization, text clustering, entity/terms extraction, but this is not enough for our purposes. The analysis of the text material collected through linguistic tools (morphological engine and tagger), is essential for a subsequent productive application of the statistical functions of extraction.

Our aim is to develop not only tools for the analysis and synthesis of linguistic evidence, but also for the creation of terminological data bases and linguistic resources specialized for textual analysis.

We have also experimented a system for text categorization as content filter to be provide on demand.

#### 3.2.1. DBT & Faccette

“DBT & Faccette” is a labeling and text analysis system, born as customization of the traditional faceted<sup>2</sup> classification system. This system is not limited to the identification and classification entities, but is also able to identify the particular relations between the entities involved.

This approach allows the automatic reorganization of content, based on the semantically relevant concepts extracted from the text, and allows the user to dynamically discover the concepts semantically relevant for the domain. In this way it is possible to carry out search refinements through the interrelated concepts.

Below is a simple example of research. If you want to find the word “*stile barocco*”, it is possible to refine the search on the basis of all concepts and terms related, which are in the same set of documents.



Ricerca

stile barocco / centro storico / madonna del carmine

Faccette

Chiedi

Trovati: 33

Faccette

decescente - alfabetico

Ricerca

basilicata 9

salvatore sebaste 8

de luc 6

potenza 5

padova 4

pallotto 4

sant'antonio 4

padula 3

lucia 3

anime purganti 3

culture 3

ganbaldo 2

proce latina 2

anfiteatro 2

tricarico 2

madonna del carmine 9

ruso 6

chiesa 6

ermanno loescher 5

agnò 4

sanseverino 4

capella laterale 3

napoli 3

larotonda 3

benvenuto 3

misten del rosario 2

donato 2

ritratti 2

sala consiliare 2

navata unica 2

centro storico 9

anna grette 6

madonna del rosario 5

madonna con bambino 4

annunciazione 4

santa marie 4

pietrafesa 2

puglia 3

giovanni de gregorio 3

chiesa madre 3

san giovanni battista 2

leonardo 2

torre quadrata 2

del tufo 2

complesso monumentale 2

matara 8

pietro 6

giacomo radiopoli 3

gentilizio 4

fonte battesimale 4

primo piano 4

legno policromo 3

angelo lucano 3

giovanni battista 3

luppella 3

san lorenzo 2

genzano 2

palazzo ducale 2

convento francescano 2

altare centrale 2

basilicata.cc 82

1

Un'altra piaga fu l'epidemia della "spagnola", malattia infettiva, che provocò numerose vittime. Nel centro storico si può ammirare il Castello, situato nel punto più alto del paese: si tratta più che di un castello di un palazzo a pianta triangolare, con

2

volta a crociera. Interessante è la chiesa madre dedicata a Santa Maria Assunta, costruita con le pietre allargazioni dei feltri, in gran parte proprietà terriere. Ha una facciata in stile barocco con campanile rifatto nel 1856 in seguito al crollo avvenuto durante il terremoto del 1857. Nell'interno è tre navate con altare maggiore in marmi policromi sono conservati un coro ligneo

3

3 marmi policromi sono conservati un coro ligneo del 1753 opera di falegnami lagonegresi, alcuni dipinti tra cui quelli della Madonna del Rosario del 1788 e dell'Assunta, le statue settecentesche della Madonna del Carmine, di San Giuseppe e Sant'Antonio. Nelle vicinanze della chiesa madre è situata anche la cappella dell'Annunziata, che chiusa per alcuni anni è stata riaperta recentemente, la Madonna

4

da: A.P.T. Basilicata da visitare: centro storico (La Porticella) / Chiesa Madre / Cappella della Madonna della Sella / Palazzo Settembrini / Vasche di Sant'Alessio / Vili a Impena e / Lungomare Manifestazioni ed eventi: 19 marzo Festività

5

/ Lungomare Manifestazioni ed eventi: 19 marzo Festività in onore di San Giuseppe (Patrono) 13 giugno Festività in onore di Sant'Antonio 16 luglio Festività in onore de a Madonna del Carmine Altri Eventi (segnalati) . agg. al 25/05/2008

6

francosco nell'abbazia alcuni anni della sua vita), feudatari di Puglia e Basilicata gli concedevano terre, casali e chiese. Il patrimonio era vastissimo ed ancora oggi il centro storico coincide in buona parte con il sito dell'insediamento monastico. Intorno al monastero sorse il casale per la residenza dei coloni a servizio della comunità. La fine del

7

eretto dai francescani nel 1688 si trova (fig. 9) un lavabo sostenuto da un capitello, proveniente dal chiostro medievale. Dalla sacrestia si passa nella cappella della Madonna del Carmine in cui si trova dei basamenti a stampella del XIII secolo, provenienti dalla chiesa benedettina, un'altare di legno dorato e intagliato del XVIII secolo, una

8

l'ingresso del Palazzetto del Viceré con un interessante stemma cardinalizio. L'interno della chiesa (fig. 11), ad una navata con cappelle laterali, fu completamente trasformato in stile barocco nel XVIII secolo dai francescani. Entrando, a destra, sull'altare della cappella di S. Vito c'è una bella scultura lignea del santo (sec. XVII).

vacanzeinbasilicata.it /

**Fig. 3: Search with DBT & Faccette**

In the second example it defined a specific domain (in this case topic = “Sassi di Matera”) within of the more general cultural heritage domain. Hence the creation of specific reference corpus and terminological lexicon for this topic.

At the top of the page the system shows the most important terms for the specific domain and below provides a list of contexts, ordered on the basis of relevance to the topic.

Ricerca: sassi di matera

I Sassi di Matera in Internet Tags Chiudi Testo: 5dM

## Tags

Source	Score
Source_466_sassi.DBT1	100%
Source_489_sassi.DBT2	100%
Source_173_sassi.DBT3	100%
Source_304_sassi.DBT4	100%
Source_321_sassi.DBT5	100%
Source_298_sassi.DBT6	100%

**Fig. 4: Topic Sassi di Matera**

Figure 5 shows a particular document selected. In this case we can summarize the semantic value of the document by means of the terminology extracted. Show the synthesis and the document.





Fig. 5: A context

#### 4. Initiatives

The methodologies, strategies, resources and tools created in TP project allowed us to take part in some national initiatives:

- “The online dissemination of the historical, artistic and landscaped regional heritage”: project born from the collaboration between ILC-CNR and a public institution of Basilicata (Agenzia di Promozione Territoriale della regione Basilicata), for the dissemination of regional heritage;
- “SMARTCITY new solutions for content engineering and ambient intelligence in support of cultural tourism”: regional project, funded by the Tuscany region, in which we worked with private companies for the preservation of cultural heritage (in particular for tourist purposes).

#### 5. Conclusion

Our work proposes to overcome traditional categorization systems and their rigidity, by means of a set of open and adaptive terms classes, which can guide the end user in refining his/her search.

Such knowledge systems can also provide valuable support to applications for mobile devices and for the realization of geo-referenced tourist guides.

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<sup>1</sup> The word “terms” denote a sequence of lexical units expressing a concept of the domain of interest.

<sup>2</sup> We use the term “facets” to refer to such classes, extending the traditional notion of this term as in the literature

## ROMANINO'S ALTARPIECE AT CIVIC MUSEUM OF PADUA: FROM THE DIAGNOSIS TO THE SCIENTIFICALLY GUIDED INTERVENTION

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### Abstract

Physico-chemical investigations, on S. Justine's altarpiece, painted by Romanino and currently exposed at the Civic Museum of Padua, were carried out in order to identify the pictorial technique, the stratigraphic sequence, the original inorganic and organic materials and those derived from subsequent interventions, and their distribution in the sample build-up. The study of the state of conservation and of the decay processes undergone by the materials, allowed us to define the most suitable conservation procedures.

The altarpiece represents the Virgin and the Child, the Saints Prosdocimo and Justine patrons of Padua, Benedict the founder of the order and his follower and Sister Scolastica, surrounded by a series of *tondi* portraying Saints strictly connected with the history of the Basilica [1, 2].

The different tones of the painting derive from remarkable mixtures of pigments which have been identified by FEG-ESEM-EDS analysis. The  $\mu$ FT-IR and GC-MS techniques allowed the characterization of the constituent of the preparation layer, of the binder, and of the superficial varnishes.

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**Fig. 1** The Romanino's altarpiece, representing the Virgin and the Child, currently exposed at the Civic Museum of Padua. The numbers indicate the sampling points.

### Introduction

The altarpiece (Fig. 1), representing the Virgin and the Child, surrounded by the Saints Prosdocimo and Justine patrons of Padua, Benedict and his sister Scolastica, is an early work of art of Romanino (Girolamo da Romano), strongly influenced by the Lombard (Bramante, Bramantino, Zenale) and Venetian (Giorgione a Tiziano) school. A series of *tondi* encycles the frame: they represent the Piety and the portraits of Saints, strictly connected to the history of the basilica. The Piety, located at the centre on the top, is in between the Saints Luke Evangelist and

Matthias. Two of the five tondi painted in the *predella* are now lost, while the remaining other three represent a Saint bishop, the Innocent Martyrs at the centre, and another Saint drawing the sword on the other side. There are conflicting interpretations about the identify of these two Saints: according to some art historians they represent Saint Augustine and Sebastian, others proposed they to be Saint Julian and Maximums, whose bodies were discovered on august the second 1052 inside Saint Justine's basilica, together with those of three Innocent Martyrs, killed by Herod and transported to Padua by Saint Julian. This second interpretation is considered to be more likely, as it fits better with the intimate relationship between the portrayed Saints: Scolastica was the twin sister of Benedict; Prosdocimo holds the jug with the water he used to baptize Justine, Saint Maximums looks at Saint Prosdocimo, his successor to the bishop chair of Padua. Saint Julian is looking at the Innocent Martyrs, whose rests were found in a well at the entrance of the basilica which leads to the early Christian *sacellum* of Saint Prosdocimo [1, 2].

The need of restoration of this altarpiece imposed a preventative, exhaustive diagnostic investigation. The different facilities employed permitted to facilitate a deeper, iconographic, materic and technical understanding of this painting.

The bad state of conservation of the preparatory and pictorial layers, which could qualitatively be estimated by a simple visual examination, has been confirmed by a series of physico-chemical investigations.

Stratigraphic investigations carried out on significant detached samples, (Fig. 1) proved a complex stratification together with a heavy degradation. In particular, two typologies of fissures occur, one, characterized by fine crackings or fissures transversal to thickness of the pictorial layers, the other one containing fissures parallel to the pictorial strata, especially in the areas closer to the preparation surface. Sometimes, in addition to the fissures, also variously extended and fragile detachments occur, possibly due both to ageing processes of the pictorial layers and to the shrinkage and stretching of the wooden fibers of the altarpiece. Invasive last interventions, especially the use of particular aggressive materials for the cleaning procedures, caused a remarkable decay phenomena.

Widespread partial decohesion phenomena have been found between the preparation layer and the wooden support and more relevant between the preparation layer and the paint ones. The strongly damaged varnish (i. e. variation of the colour to yellowish or brownish, cracks, etc.) did not allow a correct view and evaluation of the variety of different tones. Thus, integrated non destructive or micro-invasive analyses (FEG-ESEM-EDS,  $\mu$ FT-IR and GC-MS) have been carried out in order to have a correct knowledge of the inorganic and organic materials present and their conservation state the possible decay processes, in order to design the most appropriate intervention.

This study represents an example of the role of a scientific approach to the evaluation, in the close connection with historical-artistic studies, of the problems to be solved for a correct conservation of paintings.

### Sampling and analytical techniques

The collected micro-samples preliminary observed by a Wild 8-Leitz stereomicroscope, were subsequently submitted to the cross section preparation and the mechanical separation of the different layers for optical microscopy and IR measurements. The optical microscope Olympus BX-51 equipped with UV light source Olympus U-RFLT and UV filters was used to perform optical observations under visible and UV light of the cross sections, in order to identify the sample build-up and the presence of fluorescent materials. The identification of the pigments have been carried out by observing the cross sections under a scanning electron (FEI Quanta 200F FEG-ESEM), equipped with an Energy Dispersive X-ray Spectrometer (EDAX Genesys), using an accelerating voltage of 25 KeV for the semiquantitative elemental analyses. The samples were coated with a graphite film before Scanning Electron Microscopy with X-ray investigations (SEM-EDS), and the analysis have been performed in high vacuum condition. The inorganic pigments and the related products have been identified according to the presence of characteristic elements and their ratio [3].

Micro Fourier Transform Infrared Spectroscopy ( $\mu$ FT-IR) measurements were carried out on the detached samples and on their soluble fraction extracted by dichloromethane, ethanol or water to determine the typologies of the employed inorganic and organic materials. A Nicolet microscope connected to a Nicolet 560 FT-IR, equipped with an MCT detector was used with OMNIC32 software [4].

The gas chromatography-mass spectrometry (GC-MS) technique was carried out to study the organic content of the paint layer and of the superficial varnishes, and the degradation level of the materials. In particular nine micro samples collected from the altarpiece and the *tondi* were subjected to part of the analytical procedure described in the literature, in order to determine the lipid and resinous content [5]. The samples were subjected to saponification assisted by microwave, with an ethanolic solution of potassium hydroxide (10%). After saponification the hydroalcoholic solution was diluted in bidistilled water and an extraction with hexane, followed by an extraction with diethyl ether (after acidification) was performed. Finally, an aliquot of this extract was subjected to derivatisation with N, O-bis(trimethylsilyl)-trifluoroacetamide (BSTFA) and analyzed with GC-MS system.

### Results and discussion

#### Pigments

Optical and FEG-SEM-EDS stratigraphic studies of the cross sections of the sampled fragments showed a quite complex stratigraphy: according to the painting technique in use at Romanino's time, a white lead priming was superimposed to a preparatory layer containing gypsum and animal glue quite often used for obtaining a brighter



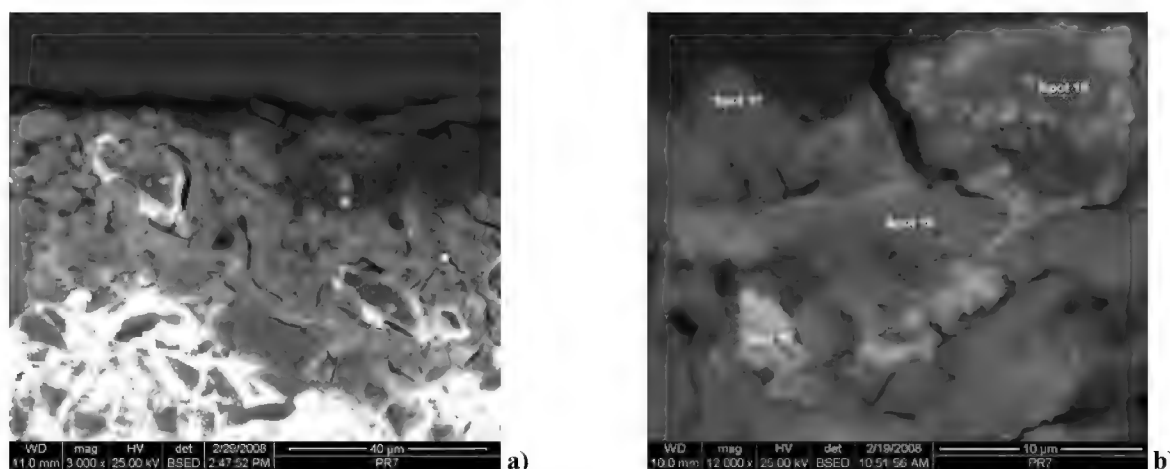
effect. Furthermore, these investigations permitted the identification of the original pigments and their mixture in the paint layers to obtain peculiar chromatic effects.

The Romanino's palette was found to be quite rich in the content of precious and different mixture of pigments. In succession we report a short description of the different pigments, binders and varnishes identified.

#### ■ *Blues*

The different blue tones derive from lapislazuli variously mixed with white lead. The blue mantle of the Virgin, for example, contains two layers of lapislazuli and white lead above a preparation of white lead. On the contrary, Saint Justine's blue dress derives from a grey preparation of white lead and carbon black, followed by a layer of lapislazuli mixed with madder lake particles [6].

The peculiar technique to obtain the shadings on the lapislazuli containing background of the Virgin's mantle is quite remarkable. In fact, a stratigraphic investigation of an appropriately selected fragment proves that no particular pigments were employed to darker specific areas of the blue mantle of the Virgin: above a white lead preparation these areas contain two subsequent blue layers of lapislazuli mixed with different amounts of white lead. These observations prove that a higher amount of white lead brightens the blue tones of lapislazuli, while the darker shadings derive from the only use of lapislazuli (Fig. 2). Historical documents of the lapislazuli production in the XVI century offer two reading keys to justify the absence of black pigments in these shadings, one belonging to the pictorial technique and the other to the physical properties of the pigment. Specific studies on an appropriately detected fragment, focused to verify whether a different lapislazuli granulometry can induce the detected chromatic variations, prove a non significant variation of the grain dimensions of this pigment in the two pictorial layers: little higher lapislazuli grain dimensions in upper darker layer was found, not enough, however, to justify the different tones. Thus, the use of the pictorial technique reported in Cennini treatise [7] seems to be the most plausible cause of such differences. This technique, in fact, implies the employment of the pure pigment in the dark areas, progressively mixed with different amount of white lead to obtain the brighter areas. The proposal is corroborated also by the low amount, or the absence in some areas, of white lead in the darker layer of the investigated sample. The slightly different pigment granulometry, occurring in the two pictorial strata may be ascribed to the use of lapislazuli of different quality, normally obtained during the purification process of the pigment.



**Fig. 2** BSED micrographs of surface blue layers (3000X) (a), and of lapislazuli grains in the grey layer (12000X) (b) of the sample PR7.

#### ■ *Yellows and Oranges*

The orange garments of Saint Justine and of the Angel on the right of the throne contain arsenic, belonging to orpiment [8]. In particular, the orange colour of Saint Justine's dress is due to the superimposition of two layers containing ochre, natural earths and orpiment [9]. Furthermore, madder lake grains were detected in the brighter, very powdered and with the finest granulometry areas, mixed with orpiment [8]. Yellow ochre and earths again mixed with orpiment give particular tones to the yellow and orange backgrounds. According to the presence of Pb and Sn, the yellow backgrounds contain *giallolino* and yellow ochre, mixed with white lead in the decorations of Saint Benedict's suit while a yellow ochre or Sienna earth was used for the yellow background of Saint Prodocimo's stole. In addition, the brown area of this stole derives from a dark red stratum of red ochre layered above a blue one of azurite mixed with rare red lake particles [10].

#### ■ *Greens*

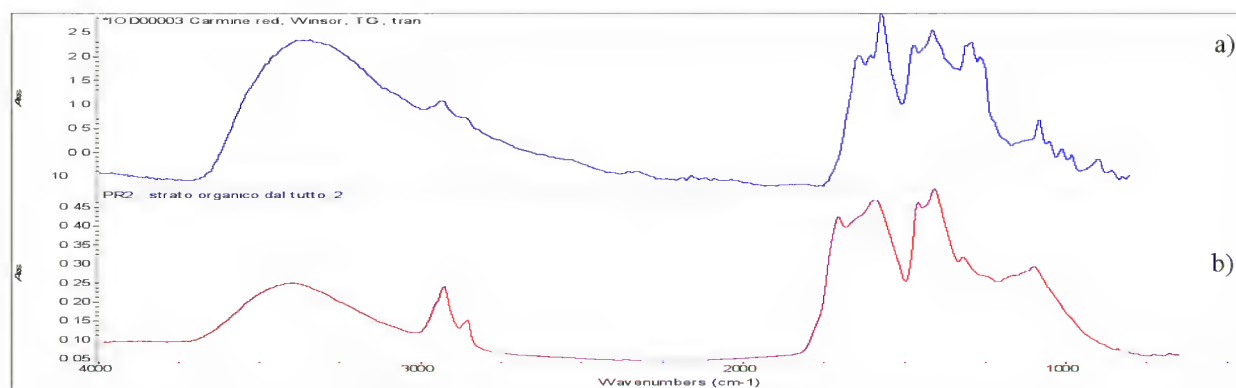
The green areas are due to copper-based pigments (malachite and verdigris), mixed with white lead and/or lead and tin yellow [6]. Two successive layers of verdigris mixed with a small amount of white lead and lead and tin yellow gives Saint Justine's tunic the green tone. The presence of copper occurs also in differently coloured areas, for instance in a dark area containing the red garment of the central musician because of the presence of madder lake, in



the highlighting close to the fringe of the Angel's suit, in the dark background of Saint Scolastica's dress and in Saint Prosdocimo's bourgeois stole.

### Lakes

The red lakes, preliminary identified as madder lake by IR and fluorescence data, were used not only to obtain a vivid red colouration as occurs, for instance, on the Virgin's dress, but also to give peculiar shades to the other pigments (Fig. 3). They have been found together with azurite on Saint Prosdocimo's Bordeaux stole or together with lapis lazuli on the Saint Justine's blue dress [8].



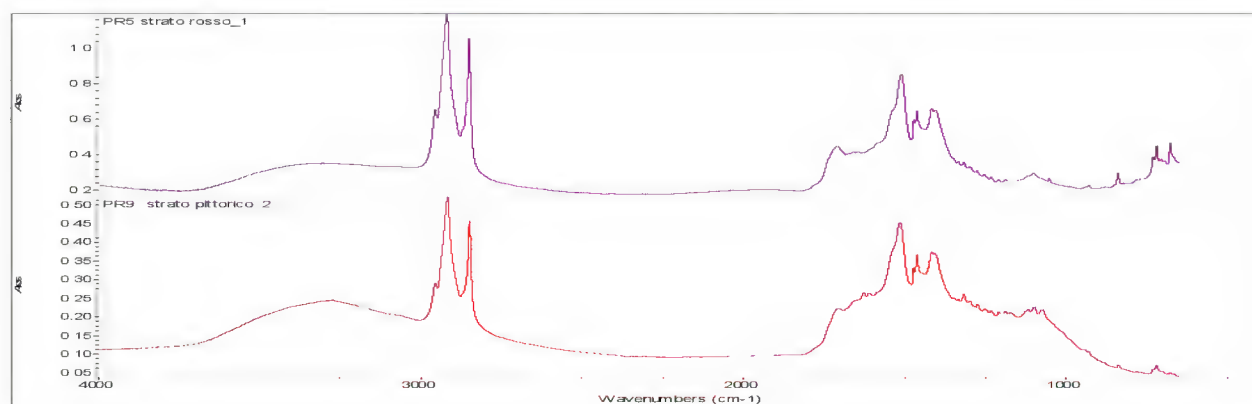
**Fig. 3** Ir spectra of reference madder lake (a) and of the red lake extracted from the sample PR2 (b).

### Binders

The detached samples subjected to extraction with proper solvents for the characterization by  $\mu$ FT-IR of organic materials show:

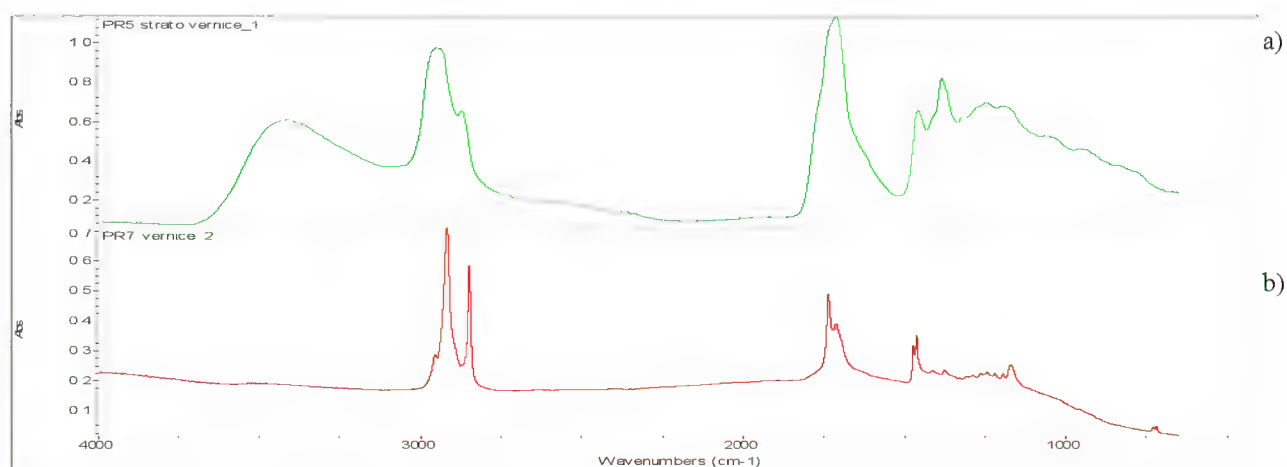
- animal glue in the gypsum preparation strata;
- siccative oil as pictorial binder;
- terpenic resins as varnishes, particularly widespread are the mastic and dammar ones;
- the occurrence in one sample of wax suggests an occasional use of beeswax as restoration material.

Some explanatory example of the IR investigations are reported in succession. The IR spectra reported in Figure 4, show the presence of a siccative oil in the paint layers, which have been separated by the others layers by using scalpel under optical microscopic observation. Furthermore, the occurrence of bands due to carboxylate groups ( $R-COO^-$ ), clearly indicates a heavy degradation process due to hydrolysis of the long chains esters ( $RCOOR$ ), probably caused by their interaction with the metal ions and clusters of the pigments. Moreover the IR analysis permitted the identification of animal glue and gypsum in the white preparation layer.

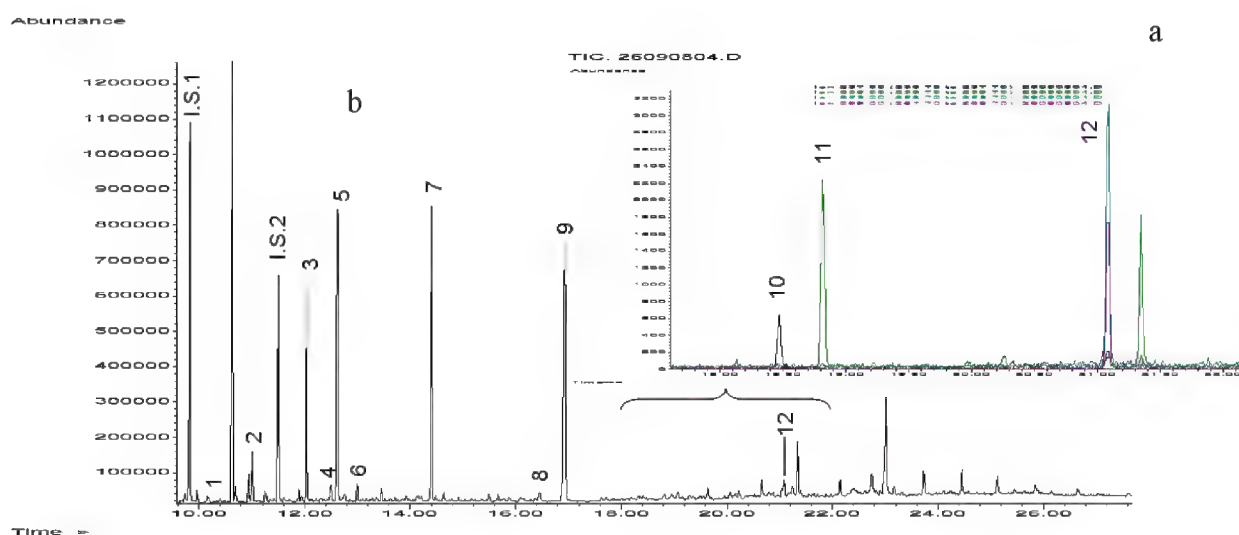


**Fig. 4** Ir spectra of damaged fraction of a siccative oil in the paint layers of sample PR5 and PR 9.

The IR spectra of the superficial layers which have been selectively separated from the paint ones by using scalpel show the presence of a varnish belonging to a terpenic resin (mastic or dammar) (Fig.5). On the surface of one sample (PR7), also fatty esters containing long chains have been detected, in fact the feature of these spectra are consistent with those of waxes. Finally, IR analysis allows the identification of madder lake in samples PR2, PR5, verdigris in sample PR4, PR8, lead white in sample PR6 and PR7 and Prussian Blue in sample PR6. The variety of pigments belonging to different periods, the occurrence of different resins, together with an occasional presence of wax, confirm the numerous interventions on this works of art [11, 12, 13].



**Fig. 5** Ir spectra of the superficial varnish layer: (a) the terpenic varnish in sample PR5; (b) long chain saturated esters, comparable to those of waxes in sample PR7.



**Fig. 6** Gas chromatogram of the lipid fraction of sample PR1 (a) and corresponding extract ion chromatogram (b) of the ions with  $m/z$  237, 239, 253, 268 (characteristic of the markers of the Pinaceae resin) of sample PR1, where S.1: hexadecane, I.S.2: tridecanoic acid-TMS, 1: lauric acid-TMS, 2: suberic acid-2TMS, 3: azelaic acid-2TMS, 4: miristic acid-TMS, 5: 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester (pollutants), 6: sebacic acid-2TMS, 7: palmitic acid-TMS, 8: oleic acid-TMS, 9: stearic acid-TMS, 10: didehydroabiatic acid-TMS, 11: dehydroabiatic acid-TMS, 12: 7-oxo-dehydroabiatic acid-TMS

The GC/MS analyses were performed on the samples which weights were lower than 0.1 mg to exhaustively characterize the organic materials present in the superficial layer. The study of the lipid and resinous fractions revealed that all the samples contain a low amount of fatty acids varying between 0.4 and 6  $\mu\text{g}$ . However, although the samples were very small, the presence of a siccative oil was recognized in the samples, with the exception of the sample PR6 coming from the *predella*, on the basis of quantitative analysis of monocarboxylic and dicarboxylic fatty acids. In particular, the characteristic ratios of azelaic acid on palmitic acid (A/P), palmitic acid on stearic acid (P/S), oleic acid on stearic acid (O/S) and the sum of the dicarboxylic acids ( $\Sigma \text{Dic.}\%$ ), are consistent with the presence of a linseed oil (as an example for PR4 A/P=1, P/S=1.32,  $\Sigma \text{Dic.}\%=37$ ) [14]. Furthermore, the high values of the A/P ratios and  $\Sigma \text{Dic.}\%$  in sample PR3 (A/P=4.6,  $\Sigma \text{Dic.}\%=72$ ) prove that a prepolymerised linseed oil has been used during past restoration [15].

Moreover, in the lipid fractions of most of the samples, the presence didehydroabiatic acid, dehydroabiatic acid and 7-oxo-dehydroabiatic acid, even if in low amount respect to the oil, attested the presence of a Pinaceae resin. In sample PR6 coming from the *predella* the Pinaceae resin was present just in traces, while it was absent in sample PR7. GC-MS does not detect varnish in this sample owing to a quite possible detachment. IR spectra however, clearly show bands due to a terpenic resin. This shows that a series of different measurements are necessary to have

an exhaustive view of the materials inside the sample under investigation. Figure 6 reports the chromatogram of the sample PR1, chosen as an explanatory example, where the markers of a Pinaceae resin, together with the fatty acids are clearly detectable.

### Conclusion

The restoration of Romanino's altarpiece of Padua offers a unique opportunity to carry out integrated non-destructive and micro-invasive investigations, aimed at elucidating the pictorial technique, the presence of materials of different periods, superimposed to the original ones and to evaluate the state of conservation.

The different physico-chemical measurements identified the nature of the pigments, the materic mixture employed to obtain the different chromatic tones, and binders present in the pictorial layers and the surface varnishes. Microscopic investigations on the cross sections of the detached fragments showed a quite complex stratigraphic sequence and an unsatisfactory conservation state.

The quite thick, often double preparation layer contains gypsum and animal glue, sometime mixed with calcium carbonate and silicatic grains. The different chromatic tones derive from quite sophisticated mixtures of pigments. The orange of Saint Justine's dress, for instance, is due to two subsequent layers of ochres, natural earths and orpiment, mixed gypsum and carbonate grains of calcium and magnesium (possibly dolomite) in the upper stratum. Furthermore, the Virgin's red dress shows a stratigraphic sequence of madder lake and white lead, a red lake containing white lead and animal black and a dark red glazing also containing the same red lake. The green tone of Saint Justine's tunic is due to two subsequent pictorial layers containing verdigris mixed with rare particles of white lead and lead and tin yellow (*giallorino*), while her white dress derives from a unique very porous white lead layer. The brown tone of the stole on the arm of the bishop Saint Prosdócimo is due to a dark red stratum of madder lake, layered on a blue one containing azurite and rare madder lake particles.

The yellow background of Saint Benedict's damask mantle is obtained by using lead and tin yellow (*giallorino*), and yellow ochre mixed with white lead, while the red decorations derive from a layer of red lake and white lead. A white lead preparation followed by two subsequent strata containing lapislazuli, variously mixed with white lead, gives Virgin's dress the blue tones. While the first blue pictorial layer looks quite bright, the second one is grey, causing a duller chromatic effect. On the contrary, the blue tone of Saint Justine's dress is due to a grey preparation of white lead and carbon black, followed by a stratum of lapislazuli mixed with white lead and red lake.

Finally the rosiness of the musician Angel underfoot the Virgin was obtained by laying a white lead stratum of red earth and lead or calcium and magnesium containing grains above a grey brown preparation of white lead mixed with carbon black and brown earths.

The binders and varnishes were primarily characterized by their extraction with appropriate organic media from the detached micro-fragments. The IR and GC-MS analysis of the samples and of the extracted organic fraction, indicate the presence of animal glue in the gypsum preparation, siccative oils as organic binders, and a mixture of different terpenic resins and siccative oils (occasionally also prepolymerized) as superficial varnishes. The ascertained formation of carboxylate groups, in consequence of hydrolysis of the related esters containing long chains by inorganic materials i.e. the lead, tin, copper ions, etc. of different pigments, in several pictorial layers, clearly indicates an heavy degradation of these organic materials. IR and fluorescence data of the red particles indicate the presence of madder lake.

Microscopic investigations offered a careful view of the morphology and of state of conservation of the different pictorial layers, the adhesion of the strata and fissure formation. In some fragments different fissuring typologies have been detected in the strata: fine craquelures and non-relevant transversal cracks from the surface toward the inner layers, in some fragments in other fragments parallel cracks to the strata occur, especially between the preparation and the pictorial layers. Finally the surface varnish does not appear to be the original one; likely, it was applied in consequence of subsequent clearing procedures; above the varnish layer, in fact, residues of organic strata containing dust deposits, not completely removed during the cleaning procedure have been detected.

In conclusion, the physico-chemical and analytical investigations prove the use of quite sophisticated pictorial technique, attested also by the complex stratigraphic sequences. Romanino used only pure pigments to underline the different darker areas (for instance shadings background etc.) and the same pigments variously mixed with others (i.e. white lead, madder lake, etc.) in the brighter areas. This painting technique is in agreement with that reported in Cennini's treatise.

Furthermore the scientific investigations attest the bad conservation state of the altarpiece and the need of a restoration. The final intervention, scientifically guided by a correct materic knowledge, restored the original chromatic equilibrium to the whole painting, allowing a correct comprehension, contemporary facilitating a more appropriate enjoyment by a wider audience.

### Acknowledgement

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# DEVELOPING INTERCULTURAL CONSCIOUSNESS IN SCHOOL CHILDREN: INTERACTION BETWEEN SCHOOLS AND MUSEUMS

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**Keywords:** Education, Geoscience exhibitions, Geosites preservation, Cultural development, Economic development

## 1. Introduction

During the International Year of Planet Earth (2007 – 2009) two temporary and itinerant exhibitions were designed and prepared in a local Museum of Natural History in the context of the Project “To understand how the Earth works: from local situations to global processes”, devoted to the diffusion of the geological culture. The Project was promoted by the Museo Civico Craveri di Storia Naturale (Bra, Cuneo, NW Italy) and by the Earth Sciences Department of the Turin University.

The project takes root from the many activities of cooperation and partnership jointly undertaken by the Piemonte Region and the Cape Verde Republic in the last decades, which allowed visiting and studying the archipelago and its culture, then getting data and geological samples of great value for exhibitions [1, 2].

The exhibitions were designed by a multidisciplinary team of teachers and experts on Natural Sciences and Geology [3, 4].

## 2. Aims and goals

The main purpose of the project is to document important sites of great value for their uniqueness or didactic effectiveness in different fields of the Earth Sciences. This goal has its foundation in the belief that Cultural Heritage includes Environmental heritage: peculiarities of the physical environment, if recognized and thoroughly preserved, can allow a conscious fruition of the territory and promote cultural and economic development [5, 6]. Some geosites need to be preserved for their singularity, others are important for their didactic potential.

Intercultural relationship, gained through the comparison among peculiarities coming from different geographic areas, allow to understand the connections between local and global events.

## 3. The exhibitions: contents and formative offer

The exhibitions, entitled “To know in order to live with the volcano” (Figure 1) and “Treasures and secrets of the coastal environment” (Figure 2), show two emblematic environmental situations



**Fig. 1** – Exhibition “To know in order to live with the volcano”. The panels refer to the natural park of the island of Fogo and show activities of cooperation and partnership between the Piemonte Region and the Cape Verde Republic.

of Cape Verde territory (the volcanic and the coastal environments) having analogues in the Mediterranean area, in terms of demands of valorization and protection of the geological heritage (Figure 3). Prominence is given to the existing constant interaction between the natural environments and human activities, with a particular attention to the geological and geomorphological processes of internal and external origin, both contributing to landscape evolution and natural hazards. At the same time attention has to be paid to the impacts generated by human activities, both at the local or global scale.

The exhibitions were introduced to the public through conferences. Self-guided tours to exhibitions were addressed to a non-specialized public; guided tours and practical laboratories were addressed to schools (Figures 4, 5); interactive lectures on Earth Sciences were offered to in-service teachers (Figure 6).

#### 4. Education strategies

The exhibitions include panels, showcases (Figure 7), multimedia devices and interactive activities. The latter are the main subject of the guided tours and practical laboratories.

Different didactic paths are prepared for students of different age, from nursery to high school. For all of them particular attention is paid to integrate cognitive activities with recreational activities, to stimulate both mental, sensorial and emotional levels of the experience, to give value and joyful care to the individual participation of the visitors, to their personal way of interpreting the panels and the samples exposed, to propose solutions to the posed problems (Figures 4, 5).

The targets are to generate emotional involvement, to stimulate interest and curiosity, to develop debates among visitors, to widen view points on topics of relevant scientific and social value. It is well known, according to the literature in didactic research, that this strategy is highly effective in producing better attention, personal involvement, long lasting learning [7, 8].

Students are invited, through interactive strategies, to recognise events, processes, landforms at risk, hazards for the population, and to compare all this with homologous or analogous situations well known in Italy or generally in the Mediterranean area. Aiming to a sustainable development, it has been stressed the importance of acquiring adequate knowledge on these fragile environments, and it has been evidenced the necessity of their preservation [9].

#### 5. Interactive and experimental activities

Geological structures are not generally accessible to direct inspection. They are often misunderstood by students and take great advantage by didactic tools involving questioning and discussion. For this reason the volcanic structure is explained through a panel that can be partitioned and that show gradually the different parts of a volcanic island (Figure 5).



**Fig. 2** - Exhibition “*Treasures and secrets of the coastal environment*”. The panels show human settlements along the coast and the impact that these activities have on the coastal environments. Painted murals in the villages represent remarkable aspects of the territory, and show great affective concern for the environmental defence.



**Fig. 3** - Comparison between Cape Verde and Italy. Despite their geographical distance, they share several common aspects. The same geomorphological processes, of internal and external origin, influence the landscape evolution and produce natural hazards.

Drawing technique is another tool used in both the expositions to approach themes like volcanic structure and coastal shapes: the effectiveness of drawings consist in the variety of information provided [10]. For example, a drawing of a volcanic island can provide great information on thinking of students on both the geology and the relations between the volcanic environment and its inhabitants (Figure 11).



**Fig. 4** - Interactive activities and practical laboratories addressed to schools.

Before visiting the exhibition on the coastal environment, students are requested to recall and represent with a drawing their first contact with the sea. The emotional involvement is clearly expressed in most works and greatly influences the visit (Figure 8).

Listening of sounds is another emotional tool used: visitors are invited to listen to different sounds, to recognise them, to connect them with their feelings and to express if the sounds can be connected to hazard situations. Different sounds can be related to the same event, the consequences of an event can be related both to a benefit (growing of flowers) or to a danger (lightning) (Figures 9-10).

Practical work is offered in the laboratories: activities with rock and fossils samples, landscape analysis through picture interpretation. These activities are opportunities of multiple sensorial experience and represents a link between the samples exposed in showcases (Figure 7) and the panels. The didactic path is completed when it includes field work and meta-cognition over the performed activities.



**Fig. 5** - Interactive activity in guided tours explains the internal structure of a volcanic island. The part of the island emerging from the sea is only a small portion of the entire structure, that reaches the bottom of the sea floor.



**Fig. 6** - Cooperative Learning methods in an updating course for in-service teachers. Working groups are manipulating samples of different rocks.

## 7. Conclusions

Both exhibitions have an itinerant character, and after having concluded experimentation in Italy, panels will be translated and activities will be adapted to be offered both to Cape Verde population and tourists.

The knowledge of a diversity of territories, others than that one belongs to, allows a deeper knowledge of the territory and its problems and represents a significant stimulus to evaluate and visualize effects of local actions on the planet Earth, through time and space.

The abundant material collected (samples, photographs, books and videos) belongs to the rich collections of the Museo Civico Craveri di Storia Naturale di Bra, concerning the natural environment of the Cape Verde Archipelago (Eastern Atlantic).

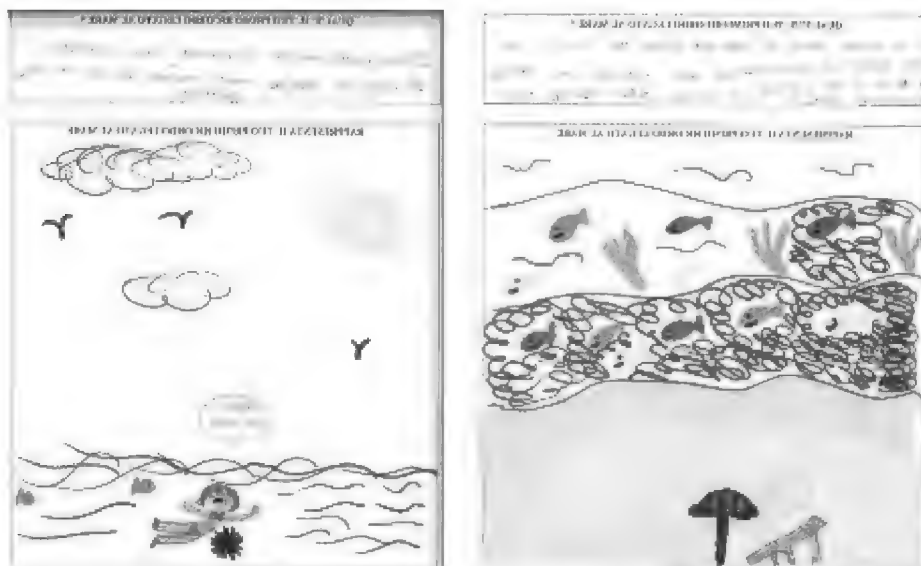
## 6. The research-action

The guided tours were sustained by the professionalism of museum operators, who also played a role as researchers: exhibitions activities were monitored, collected data were elaborated, being part of a research-action project [11, 12, 13] committed to the quality control of present-day activities and to their proactive future modifications (Figures 8-11).

The museum operators play in fact a vital role. They have a specific training and are involved in the project not only at the level of mastery of content, but they also share the values and the teaching strategies to be adopted to transmit them. In particular, the pedagogical approach adopted prefers the constant interaction with pupils. The museum operators question the students, encourage them to expose concepts and discuss concerns with their peers, they mediate discussions and participate at the same time.



**Fig. 7** - Showcases of samples include: samples of volcanic and sedimentary rocks, fossil and recent shells, coral colonies and skeletal remains.



**Fig. 8** - Students are requested to recall and represent with a drawing their first contact with the sea. The first drawing records a "feeling of fear", the second one shows a quiet and attentive attitude.



The analysis of the evaluation and the satisfaction tests given to students and teachers show the appreciation about both the exhibitions: most of students would come back to visit them; teachers state that visits were pleasant, that their pupils were satisfied and that visits were useful in terms of learning.

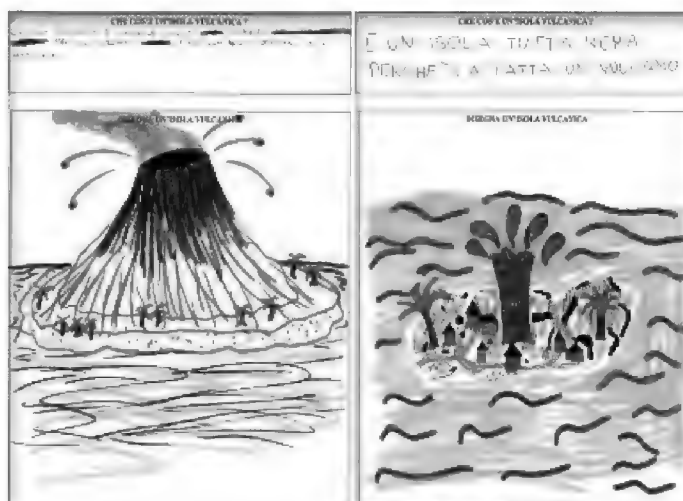


**Fig. 9** - Sounds activity. Children listen to different sounds and then represent them by means of a drawing.



**Fig. 10** - Sounds activity. Example of graphic representation of the activity. The sound listened, produced by the rain, evokes the storm to a child, the flourishing of flowers to another.

**Fig. 11** - Examples of graphic representation of the idea of "Volcano". The greatest part of the analyzed drawings represent a volcanic island without human population. The concept of geologic hazard is well expressed where human settlements are present.



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## **NATURAL INSTABILITY PHENOMENA: FROM HAZARD TO OPPORTUNITY OF CULTURAL TOURISM THE CASE OF THE BELVEDERE GLACIER (MONTE ROSA GROUP, ITALIAN ALPS), AN OPEN AIR MUSEUM OF INTERNATIONAL RELEVANCE**

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Italy is a country rich of historical heritage and of natural sights, densely populated and affected by very active geodynamic processes. Several ancient towns are very often subject to natural hazards of different kind: Florence is prone to flooding from the Arno River; L'Aquila has been recently hit by a strong earthquake; Orvieto is involved by landslides, etc. In all these cases the relevance of natural hazards is much less than the relevance of the cultural assets. In the case of the city of Naples, on the contrary, the Vesuvio volcano, famous for its catastrophic eruptions, takes a cultural interest of equal rank. The symbiosis Naples-Vesuvio is an example of interconnection between natural products and the products of human skills and both can be considered real resources of the territory. In recent years, there's a trend towards the creation of a catalogue of environmental features, particularly suitable to describe and witness the history of the Earth (geomorphosites) because of their scientific, didactic, cultural, scenic, socio-economic properties. The beautiful Belvedere glacial basin, on the eastern face of Monte Rosa (4634 m, Western Italian Alps) is rightly considered a geomorphosite of international relevance, an open air natural museum, unique in the Alps. During recent decades an extraordinary sequence of phenomena of different origin and intensity (surge, outburst glacial lakes, ice/rock avalanches) have deeply modified the glacial basin. These geomorphologic changes produced risk situations for the village of Macugnaga, the "pearl" of Monte Rosa, an active centre of Walser culture. The development of a huge epiglacial lake in 2002 was a great threat for the Macugnaga village, but a touristic attraction at the same time. The glacier is easily accessible, the glacial forms are well exposed and in continuous evolution. A well structured glaciological path would allow hikers and school classes to approach fascinating topics that are not so popular, as Geomorphology and Glaciology. The glaciological paths can focus the touristic fluxes with a cultural target, well different from the traditional climbing- and hiking- oriented tourists, and can contribute to the local economic development. The glaciologic path of the Belvedere Glacier would show and demonstrate to a great number of people how quickly the cryosphere transforms as a consequence of climatic changes, rapidity that well represents the complexity of the fragile equilibrium of the Earth systems.

## **INTERNATIONAL COLLABORATION PROJECT FOR THE CONSERVATION CENTER IN THE GRAND EGYPTIAN MUSEUM IN CAIRO**

**KEIKO KUROIWA**

*Mission Member (Museology) for the GEM-CC project*

*Japan International Cooperation Agency*

This paper introduces briefly an international collaboration project for the Conservation Center in the Grand Egyptian Museum (GEM-CC).

The Egyptian Government constructed GEM-CC with an Egyptian budget and Japan International Cooperation Agency (JICA) has been implementing technical cooperation since June 2008.

GEM-CC aims to conserve artifact and plans to work as a place to offer a wide variety of professional training to colleagues such as conservators and scientists from all over the world in the future.

Some Egyptian staff has visited several Japanese museums, cultural institutions and companies as part of the training. JICA has also dispatched various experts from Japan and other countries to Egypt in order to provide Egyptian staff with hands-on training in cooperation with the Japan Center for Cooperation in Conservation, the National Research Institute for Cultural Properties, Tokyo.

# SESSION D2 - MUSEUMS MICROCLIMATE AND MONITORING

## INTELLIGENT MOBILE ROBOTS FOR THE SURVEILLANCE OF CULTURAL HERITAGE

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### Abstract

The development of fully automated surveillance and safeguard systems based on mobile robots is an active research area. Equipped with various sensors, mobile robots may provide reliable monitoring systems for museums and cultural sites. This paper presents part of recent and current research of the authors concerning the development of an autonomous surveillance mobile robot. The platform is equipped with different sensors, and takes advantage of a hybrid control framework to perform multiple tasks. In this work, we focus on environment mapping and surveillance using RFID technology.

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**Keywords:** Mobile Robotics, Surveillance, Mapping, RFID.

### 1. INTRODUCTION

The increasing need for automated surveillance systems has stimulated the development of novel intelligent solutions based on mobile robots [1, 2]. Using mobile robots, a surveillance system evolves from the traditional passive role, in which it only detects events and triggers alarms, to an active role, in which a robot can be used to interact with the environment (e.g., manipulating objects, removing obstacles, finding exit pathways), with humans (e.g., indicating emergency exits, prohibiting access to forbidden areas), or with other robots for cooperative actions [3]. However, differently from the mature and widespread fixed surveillance systems, mobile robot guards are still in their initial stage of development, and many issues are currently open for investigation.

A major challenge for mobile robotics surveillance is that of providing the robot with a suitable knowledge of the environment to both navigate safely and perform inspection tasks. Furthermore, in order to effectively exploit mobility and multi-functionality, it is important to develop integrated approaches capable of properly describing and addressing all the problems within a unified modelling and decision-making approach.

The objective of our work is the development of a Surveillance Mobile Robot (SMR), which tackles these issues, based on a hybrid control framework [4]. The platform is equipped with different sensors, i.e. a laser rangefinder, an RFID device, and a camera (see Figure 1), and is able to accomplish several tasks [5].

In this paper, after a brief description of the SMR platform, we focus on the software modules concerning environment mapping and surveillance, based on the use of RFID technology. Specifically, we describe our method to automatically localize several passive tags in a map of the environment, using an autonomous mobile robot. The proposed approach allows one to construct an *RFID-augmented* map, i.e. a map enriched with information stored in RF transponders. Such a map may be employed by the mobile robot for navigation purposes, as well as for goods monitoring, in a typical museum environment. In fact, if all the cultural goods in a museum were labelled by RFID tags, the robot could navigate throughout the environment and, at the same time, it could easily perform inspection tasks, like identifying the goods, detecting removed items, and so on.

### 2. THE SURVEILLANCE MOBILE ROBOT (SMR)

The SMR consists of a commercial platform, i.e. PeopleBot by MobileRobots Inc., equipped with sonar and infrared sensors, a SICK LMS-200 laser range finder, an AVT Marlin IEEE 1394 FireWire monocular camera, and an Alien Technology's ALR-8780 reader with two external circularly polarized ALR 8610-C antennas. The RFID system works at 866MHz. Passive Alien's Class 1 128-bit NanoBlock tags are employed. They consist of rectangular



targets with long side of about 10cm, containing, internally, an antenna for communication with the reader, and a microchip, which stores the ID code. Communication between the reader and the tags is performed through backscatter modulation.



**Figure 1.** The Surveillance Mobile Robot (SMR) platform.

The system has three processing units, i.e. the robot embedded PC and two additional laptops: one is used for vision processing on board the robot to perform vision-based surveillance tasks [5]; the other one is used for RFID data acquisition and storage, and application control.

The control architecture is composed of three main modules, each one connected with the sensory input: the controller module, the executor module, and the supervisor module. The controller module contains all the behaviours needed to accomplish the tasks. Multiple behaviours can be executed at the same time, if different tasks are activated. The executor module handles the execution of the tasks. The supervisor module implements the high-level functions, monitoring the mission execution and generating events through the

evaluation of sensory data. More details concerning the control system of the platform can be found in [4].

### 3. RFID-AUGMENTED MAPPING

In the last years, passive Radio Frequency Identification (RFID) is being increasingly used in mobile robotics applications, as it provides inexpensive and effective solutions to data association issues in basic navigation tasks [6, 7, 8]. Nonetheless, problems related to sensitivity of the signal to interference and reflections, and missing tag range and bearing information are open [9, 10]. Specifically, one major limitation to the use of passive RFID for mobile robot tasks is that the reader can only determine whether a tag is present or not in its reading range, while it is not able to provide information about the position of the tag.

In this paper, we describe our method for automatic localization of passive tags [11]. As in [12], we employ a mobile robot equipped with an RFID system and a laser range finder, and refer to a model of the antenna reading range for tag location estimate. Our approach, however, is different in that it uses fuzzy reasoning for both learning a model of the RFID system and locating the tags.

#### 3.1 FUZZY ANTENNA MODELLING

As a first step for RFID modelling, similarly to [12], we generated a statistic histogram for our RFID system. Specifically, we rotated the robot in front of a tag, at different distances, several times, and we counted the number of successful detections for each pose in a discrete 2D grid. It was found that the coverage map of each antenna has approximately the shape of a sector with a radius of about 2.5m and an angular aperture of about 120°. Moreover, it was observed that detection rates tend to decrease smoothly at the boundaries of the coverage map.

Such a result can be easily expressed using fuzzy logic. Specifically, we employ a zero-order Sugeno fuzzy inference system with two inputs and one output. The inputs are the range  $d$  and the bearing  $\Delta\theta$  of the tag relative to the antenna. The output  $f$  is an index defined in  $[0, 1]$  expressing the expected occurrence of detection, which we refer to as the frequency of detection of the tag. Two functions are defined for each input, labelled *Low* and *High*, respectively. The output, instead, consists of four constant values, labelled *Very Low* (VL), *Low* (L), *Medium* (M), and *High* (H). The parameters for these functions were tuned based on experimental data. The output  $f$  is given by the weighted average of all rule outputs. The *if-then* rules for fuzzy inference are reported in Table I. A representation of the input-output surface of the fuzzy logic system is shown in Figure 2, with darker grey representing higher frequencies of detection.

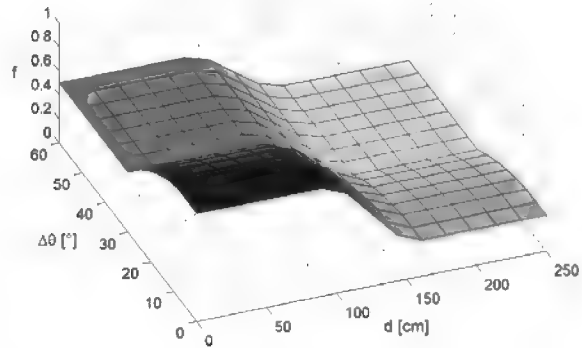
Rule #	Input 1: Tag Range (d)	Input 2: Tag Bearing ( $\Delta\theta$ )	Output: Frequ. of Det. (f)
1	High	High	Very Low
2	High	Low	Low
3	Low	High	Medium
4	Low	Low	High

**Table I.** Fuzzy logic rules for modelling the RFID reading range.

### 3.2 FUZZY TAG LOCALIZATION (FTL)

The constructed antenna model is used to localize passive tags in the environment, based on fuzzy reasoning. The main idea underlying the proposed method is that of estimating the position of a tag as the most likely location among a set of potential locations. Specifically, as a tag is detected, a set of points  $P_j$ , for  $j = 1, 2, \dots, M$ , is generated in a circular area around the current robot position. The robot, then, moves around, performing multiple tag detections from different positions. It is assumed that the robot displacement from one position to another is known. Each time a novel detection occurs, a confidence value is assigned to every point  $P_j$ , expressing the likelihood that  $P_j$  corresponds to the actual tag location.

Our hypothesis in confidence estimation is that the higher is the detection frequency associated to a point according to the fuzzy antenna model, the higher is the



**Figure 2.** Input-output surface of the fuzzy antenna model (see Table I for the fuzzy rules): darker grey denotes higher frequency of detection.

Rule #	Input 1: Frequency (f)	Input 2: Num. of views (v)	Output: Confidence (p)
1	High	High	High
2	High	Low	Medium
3	Low	High	Medium
4	Low	Low	Low

**Table II.** Fuzzy logic rules for tag localization.

to the antenna, and the parameter  $v_j^i$ , expressing the number of times the point has been found to lie in the antenna detection area. The output is the confidence level  $p_j^i$  associated to the point  $P_j$  at the  $i$ -th iteration. The *if-then* rules for fuzzy inference are reported in Table II.

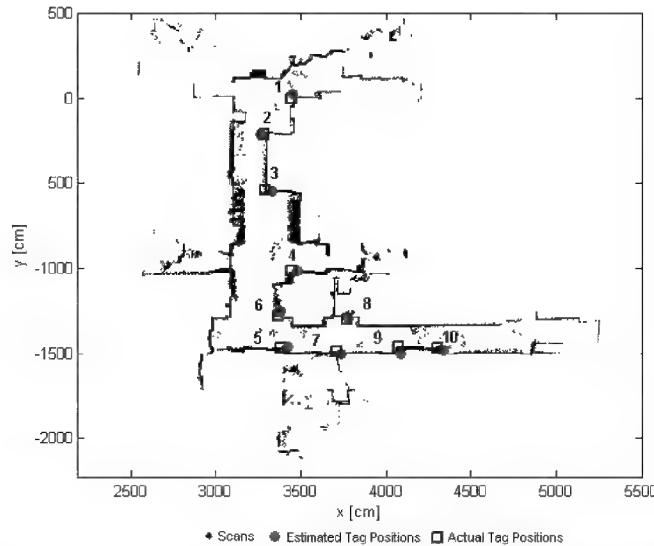
To reduce the set of potential tag locations, each point  $P_j$  is finally assigned an average confidence level. This is computed as the mean value of the confidence levels calculated for the same point in all the previous steps. Only the points whose average confidence value is greater than a threshold are retained. This process allows us to remove progressively, from the set of potential tag locations, those points that have low possibility of being the actual tag position, thus refining the estimate.

It is worth to note that if a map of the environment is available and the robot pose in the map is known from some global positioning system (e.g., using laser information), then the described procedure allows us to localize the tags in the map. That leads to what we call an *RFID-augmented map*. Such a map may provide useful information about the environment in a simple form, since RFID tags can store data either to describe interest objects and regions, or to support mobile robot navigation tasks. In the next section, we will show that such a map can improve the robot capability of performing environment monitoring tasks.

### 4. EXPERIMENTAL RESULTS

In order to validate our FTL method, we distributed ten tags in our laboratory, along an L-shaped corridor with a total length of about 40m and an average width of about 2m. Then, we guided the robot on a tour of the environment, acquiring laser and RFID data. As a first step, both the geometric map of the environment and the robot trajectory were reconstructed using a laser-based SLAM routine, based on ARNL C++ libraries by MobileRobots Inc.. The Java libraries provided by Alien Technology were, instead, employed for RFID data acquisition and storage.

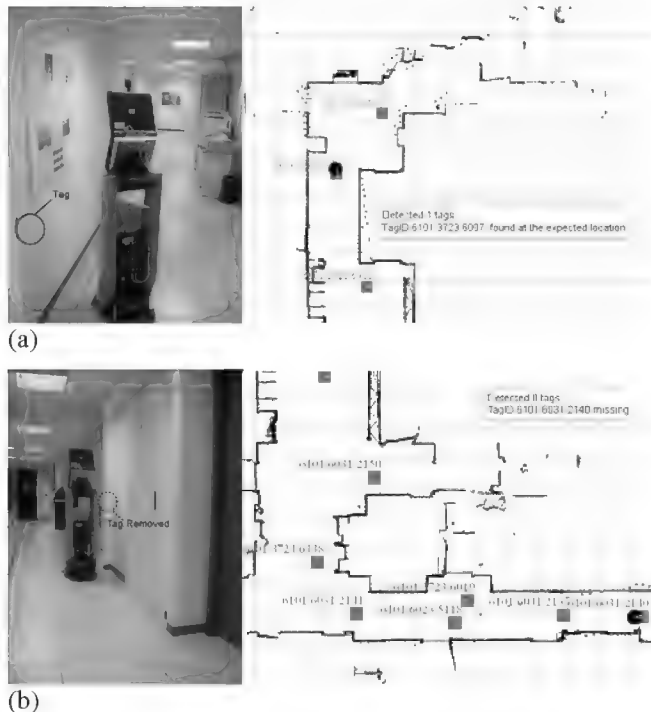
Note that information concerning different tags can always be kept separate since a tag is univocally identified by its own code. Hence, at the end of the acquisition phase, for each tag, a set of robot poses is available for tag location estimate.



**Figure 3.** Map of the environment with the tag locations estimated using the FTL module and those measured by a theodolite station.

Figure 3 shows the map of the environment reconstructed by SLAM with overlaid the locations of the tags estimated by the FTL method, compared with ground-truth measures taken with a theodolite station. We performed, for each tag, 200 detections. The algorithm was initialized with 1500 samples. The average discrepancy between the tag positions estimated by the FTL algorithm and those measured using the theodolite was less than 35cm and, in the worst case, the discrepancy was less than 50cm.

These results demonstrate that the FTL method is accurate in localizing tags deployed at generic locations of an indoor environment, with the additional advantage of relying on simple fuzzy rules.



**Figure 4.** RFID-based environment monitoring: (a) the robot detecting a tag; (b) the robot warning of a missing tag removed from its original location.

technology for environment mapping and surveillance by an autonomous mobile robot was investigated. First, a fuzzy model of the RFID reading range was constructed. Then, a fuzzy logic inference system was introduced that allows a mobile robot, equipped with an RFID device and a laser rangefinder, to localize tags in a geometric map of the environment. Experimental results show that RFID tags can be used to identify interesting regions in the map in order to support mobile robot navigation and environment inspection tasks.

The constructed RFID-augmented map can be used to support robot navigation tasks. For instance, based on RFID, a mobile robot can acquire information about its pose in the environment [13]. Vice versa, knowing its pose from other sensors, it can use RFID information for environment monitoring [14].

As an example, Figure 4 shows a navigation test, in which the robot was programmed to move in the laboratory using the constructed RFID-augmented map, in order to perform a typical surveillance task, based on the concept of goal points. A goal point is a location of the environment from which the robot observes the scene. Goal points were fixed in proximity of the tags. The robot was programmed to reach each goal and verify the presence or absence of the tag at the expected location. The pictures on the left portray the robot navigating in the environment. On the right, the output of the navigation module is shown with overlaid the output of the RFID system. Goal stations are denoted with small squares. ID codes of the tags located nearby each station are also reported.

## 5. CONCLUSIONS

In this paper, the use of passive RFID technology for environment mapping and surveillance by an autonomous mobile robot was investigated. First, a fuzzy model of the RFID reading range was constructed. Then, a fuzzy logic inference system was introduced that allows a mobile robot, equipped with an RFID device and a laser rangefinder, to localize tags in a geometric map of the environment. Experimental results show that RFID tags can be used to identify interesting regions in the map in order to support mobile robot navigation and environment inspection tasks.

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# NEW TECHNOLOGIES AND METHODOLOGIES FOR THE AUTOMATIC MONITORING OF THE CULTURAL HERITAGE

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## 1. Introduction

Monitoring cultural heritage sites is becoming a crucial problem in order to preserve public properties from thefts and vandalic actions. Nowadays these sites (hypogean and dug up architectures, necropolis, museums, libraries, ...) are monitored by using passive systems based on a set of cameras sending the acquired streams to an headquarter where one or more people, looking at monitors, have to detect suspicious behaviors. This is not only a quite tedious activity, but with increased demands of large coverage areas, continuous monitoring tasks quickly become unfeasible due to information overload for human operators.

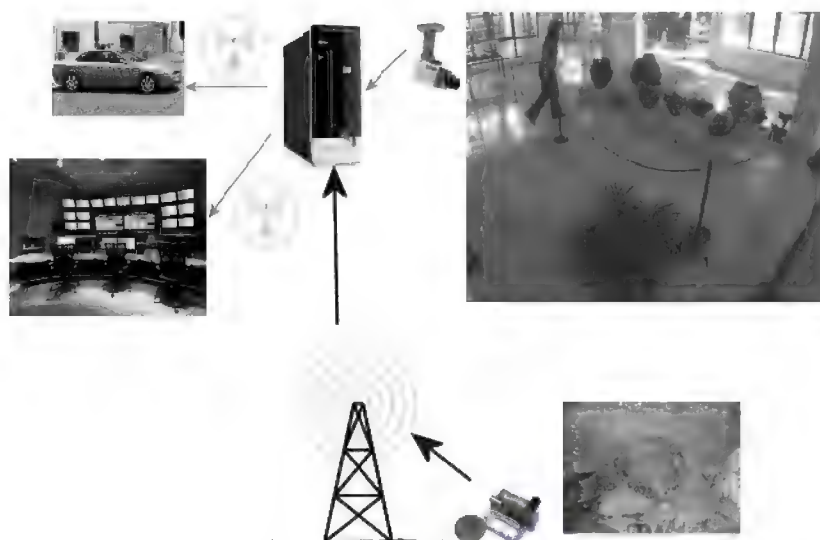
To overcome this problems a distributes framework, consisting of two different sensor typologies (cameras and MEMS inertial sensors) placed in the sites and one or more processing units able to collect the heterogeneous data and extract high level information, has been developed. In particular the proposed framework (schematized in figure 1) accomplishes three of the most important and challenging tasks in this domain: 1) *automatic detection of removal or displacement of any object in the scene*; 2) *monitoring of predefined forbidden areas*, and 3) *recognition of any human suspicious behaviors*.

The first task is accomplished by using miniaturized inertial sensors, projected with ad hoc developed technologies, that can stand up more than 15 years. Each sensor communicates, using radio-frequency technology, with the control unit that, in the case of object removal or displacement, sends an alarm by GSM/GPRS technology to the security and control operators.

The second and third tasks are, instead, accomplished by using different color cameras properly placed, calibrated and connected to processing units that analyze the acquired images in order to detect and track the people in the scene, to localize them (checking their position with respect predetermined forbidden areas) and to automatically recognize suspicious and potentially dangerous behaviors by using statistical reference models automatically generated in a preliminary training phase and continuously updated.

Depending on the scene dynamics the proposed framework sends an alarm signal (using GPRS, RF, or IP protocols) containing the information to allow a quick and effective intervention of the security and control operators.

The proposed framework has been extensively tested both in the archeological site (outdoor context) and the museum (indoor context) of Egnathia (Italy) and the experimental tests demonstrated its effectiveness both to immediately detect and to prevent any attempt to damage the cultural heritage.



**Figure 1:** A simplified scheme of the proposed framework for protecting the cultural heritage in indoor and outdoor areas

## 2. Detection of objects removal or displacement

This task has been faced by designing and implementing an architecture based on a number of MEMS inertial sensors. Each sensor is placed close to the object (buried and unburied) that has to be monitored and it sends a warning when its position changes with respect the initial one. The designed sensors are low cost and miniaturized in order to allow a pervasive and hidden use in both indoor and outdoor areas.

Each sensors has a unique Identification code and it consists of:

- The sensorial input;
- A processing unit that analyzes data coming from the sensorial input and makes decision about the advisability of sending a warning;
- A low frequency reception unit that allows to program the sensor (e.g. for inserting the ID, activate/deactivate the sensor, etc.);
- A radio frequency transmission unit that send the warning signal (transmission frequency 433 Mhz, range ~200m)
- A power supply unit.

The main characteristics of the sensor are: Miniaturized size, High collision strength, Low pollution level, Long term working life, Low energy consumption. The sensor is programmed and controlled by a control unit supplied with a display, a keyboard, a low frequency transmission/reception unit and a 9V battery. In figure II-a the designed sensor is shown and it is visually compared with a coin having the diameter of 23,25 mm. In figure II-b the unit used to control the sensor is shown. As soon as the sensor is placed in its definitive position it is activated by using the control unit and then it remains in a sleeping state until it is moved from this position. In case of movement it wakes up and forwards an alarm signal to the central unit.



**Figure II:** a) the inertial sensor used to discover in real time any movement of the buried and unburied objects. b) the same sensor included in a synthetic resin to protect it c) the unit used to remotely control the sensor.

## 3. Computer Vision Based Monitoring

The first step of this procedure is a complex preprocessing phase which extracts the binary shapes on which the following algorithms have to work.

The sequence of frames taken by a still camera is fed into a reliable foreground segmentation algorithm that combines temporal image analysis with a reference background image. To cope with lighting changes all the pixels in the background image, even those covered by foreground objects, are continuously updated in the background model [1].

After the motion detection step, foreground pixels correspond not only to real moving objects in the scene but also to their shadows. Shadow pixels have to be removed because they alter the real shape and position of moving objects.

In this paper shadow pixels are removed through a proper procedure based on the assumption that shadows are half-transparent regions which retain the same representation of the underlying background surface pattern. The implemented algorithm tries to detect moving regions that have a texture substantially unchanged with respect to the corresponding background regions [2].

After these procedures neighbor foreground pixels are aggregated by means of 8 connectivity criterion in order to build a higher logical level entity named region or blob.

Detected regions are the input to a color based probabilistic tracking procedure. The main aim of the tracking procedure is to analyze temporally the displacements of each moving region in order to manage overlapping or occlusions when the following decision making procedures could otherwise be misleading. The tracking procedure exploits appearance and probabilistic models, suitably modified in order to take into account the shape variations and the possible region of occlusion [3]. Using the procedures outlined each object is localized in the 2D image plane and is temporally tracked. Tracking information is the input to the two procedures dealing with the automatic recognition of suspicious human behaviors.

The first procedure deals with the problem of detection of forbidden area violation.

This procedure consists of two steps: firstly the 3D localization of moving regions is obtained using an homographic transformation [4]; then object positions on the ground plane are compared with those labeled as forbidden in the foregoing calibration procedure. If a match occurs the algorithm generates an alarm.

The second procedure deals with the problem of suspicious human behavior recognition by analyzing the human pose: In each frame the pose of the human beings in the scene are compared with a set of models learned in a preliminary training phase when, normal and abnormal behaviors are performed by some actors.

Human pose estimation is performed by, firstly, applying a median filtering to prevent possible flaws of the previous binarization process and then computing the horizontal and vertical histograms of the binary shapes associated to humans. To prevent scaling effect each histogram item was normalized with respect the area of the relative binary blob.

In the learning phase the referring models are built by an unsupervised clustering algorithm named BCLS (Basic Competitive Learning Scheme) [6].

The proximity measure among two postures  $Im1$  and  $Im2$  is calculated as follow:

$$D(Im1, Im2) = a * d_1(X_1, X_2) + b * d_2(Y_1, Y_2)$$

where  $d_1$  and  $d_2$  are a modified version of the Manhattan distances between the horizontal and vertical projections respectively.

In particular for the vertical projections, the Manhattan distance was defined as:

$$d_2(Y_1, Y_2) = \min \left( \sum_{j=0}^{DimY-1} |Y_1(j) - Y_2(j+i)| ; \sum_{j=0}^{DimY-1} |Y_2(j) - Y_1(j+i)| \right)$$

where the minimum is evaluated when  $i$  changes in the interval  $[0, DimY-1]$ .

In this new definition the vertical histogram of an image is compared, by the proximity measure, with all the translated version (on the left and on the right) of the vertical histogram of another one. The minimum value is taken as the proximity measure.

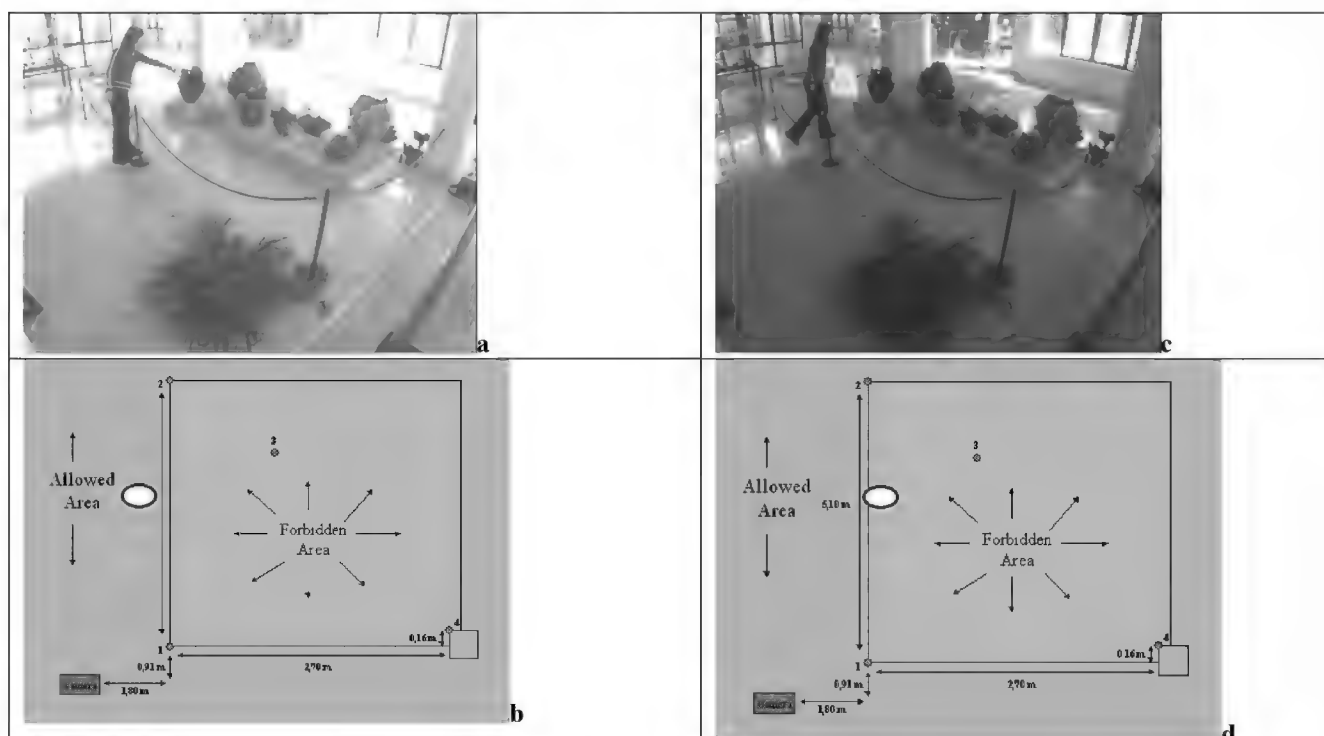
For the horizontal projection, the modified distance becomes:

$$d_1(X_1, X_2) = \min \left( \sum_{j=0}^{DimX-1} |X_1(j) - X_2(DimX-1-j-i)| ; \sum_{j=0}^{DimX-1} |X_2(j) - X_1(DimX-1-j-i)| \right. \\ \left. \sum_{j=0}^{DimX-1} |X_1(j) - X_2(j+i)| ; \sum_{j=0}^{DimX-1} |X_2(j) - X_1(j+i)| \right)$$

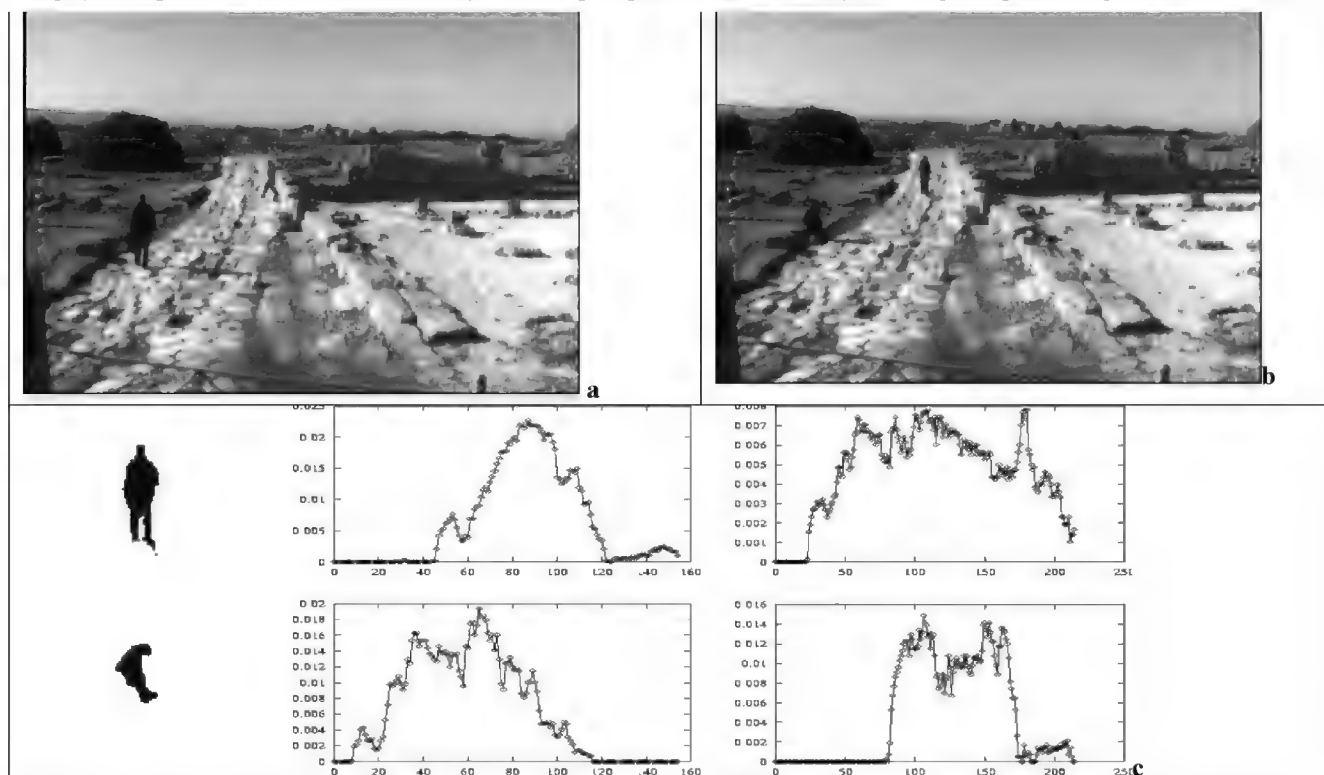
In this new definition the horizontal histogram of an image is compared, by the proximity measure, with all the translated and mirrored version of the horizontal histogram of the other one. The minimum value is taken as the proximity measure. In this way the proximity measure becomes invariant to the translation and mirroring of the binary target in the scene. The BCLS algorithms, using the proposed distance measure, permit to group the available training images using the selected features and then to classify unknown new images on the base of their relative distances with respect to the built prototypes.

## Experimental Results

Extensive experiments were performed in both the Messapic Civic Museum (indoor context) and the archaeological site (outdoor context) of Egnathia (Brindisi, Italy). The museum has many rooms containing important specimens of the past: the smallest archeological finds are kept locked in proper showcases but the largest ones are exposed without protection. The areas around the unprotected finds are forbidden areas for visitors and are delimited with cords. Only a visual control can ensure that visitors don't step over the cords in order to touch the finds or to see them in more details. The museum is adjacent to an archaeological site, i.e. a wide open area containing the remains of the messapic town of Egnathia. The archeological site consists of pathway and constructions. Visitors are only allowed to walk: they cannot touch the unburied finds or seat down on the constructions due to the possibility of collapse.



**Figure III:** Two critical situations: **a)** a visitor stays behind the limit of the forbidden; **b)** The system estimated the position of the visitor (white ellipse) on the ground and did not send the alarm; **c)** a visitor is getting in the forbidden area; **d)** the corresponding estimated position of the visitor.



**Figure IV:** **a)** a visitor in the archaeological site is walking **b)** the same visitor is sitting down on a construction **c)** the segmented blobs and the relative horizontal and vertical projections that allows the system to recognize the behavior in A as legal and the behavior in B as illegal

The miniaturized inertial sensor described in section 2 was preliminary extensively tested in the lab and then a set of sensors was placed near a hypogean tomb containing important objects constituting the funerary equipment of the buried adult.

The Computer vision based component of the proposed framework were, instead, tested to detect forbidden entry into protected areas of the museum and to recognize removed and abandoned objects and unexpected behaviors in the archaeological site.



In our experiment IEEE 1394 cameras were placed in the main room of the museum and near to the major pathway of the archaeological site. The acquired images were sent to a laptop (Pentium III, 1200 MHz, RAM 512, HD 30 Gb) where the algorithms described in the previous sections were processed. In addition a set of inertial sensor were positioned into some of the most important finds.

In figure III the main advantage of using the proposed approach to detect illegal entrance into forbidden areas is highlighted: figure III-a shows a visitor who is behind the cord but seems very close to the displayed find due to the perspective projection onto the image plane. In this case every approach based only on motion detection would wrongly detect an access violation and send a false alarm. The proposed approach instead detects the real position of the visitor (as demonstrated in the map reported in figure III-b and is able to label this situation as normal. In the figure III-c the visitor is, instead, stepping inside the limit of the forbidden area and this illegal behavior is immediately detected by the system (see the map in figure III-d where the position estimation indicates the access violation) and an alarm is provided.

Finally, in Figure IV the capability of the proposed framework to automatically recognize dangerous behaviors is pointed out. In figure IV-a, a visitor in the archaeological site is walking whereas in figure IV-b the same visitor is sitting down on a construction. In these cases the implemented algorithmic procedure, by segmenting analyzing the segmented human blob, and the relative horizontal and vertical projections (reported in figure IV-c), allows the system to label the behavior in figure IV-a as legal and the behavior in the figure IV-b as illegal.

## 5. Conclusions

This paper presented a framework to accomplish three of the most important and challenging tasks in the automatic surveillance domain: 1) automatic detection of removal or displacement of any object in the scene; 2) monitoring of predefined forbidden areas, and 3) recognition of any human suspicious behaviors.

The first task has been accomplished by using miniaturized inertial sensors that use ad hoc developed technologies. The second and third tasks have been accomplished by using different color cameras properly placed, calibrated and connected to processing units that analyze the acquired images in order to detect and track the people in the scene, to localize them (checking their position with respect predetermined forbidden areas) and to automatically recognize suspicious and potentially dangerous behaviors (loitering, vandalistic actions, writing, scratching,...) by using statistical reference models automatically generated in a preliminary training phase and continuously updated.

The proposed framework has been extensively tested both in the archeological site (outdoor context) and the museum (indoor context) of Egnathia (Italy) and the experimental tests demonstrated its effectiveness both to immediately detect and to prevent any attempt to damage the cultural heritage.

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# A MOBILE ROBOT FOR 2D AND 3D RECONSTRUCTION OF A PRE-HISTORICAL CAVE

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## Abstract

Earth holds a number of artistic and natural treasures. Many of them are still unexplored, others are known but difficult to access. In this paper, we propose a technological solution for the exploration and modelling of archaeological sites, using a multi-sensor mobile robot. We describe our 2D and 3D reconstruction techniques, and present the results of an experimental session conducted in a pre-historical underground cave, named “Grotta dei Cervi”, located in Southern Italy. Laser data were used to construct a 2D map of a corridor of the cave. 3D models of zones, rich in paintings, were also built using visual input from an on-board camera, based on feature extraction and matching techniques. The research produced valuable results, demonstrating that the proposed solution is accurate and flexible, and can be effectively employed to support the study of relevant historical treasures, guaranteeing, at the same time, their safety.

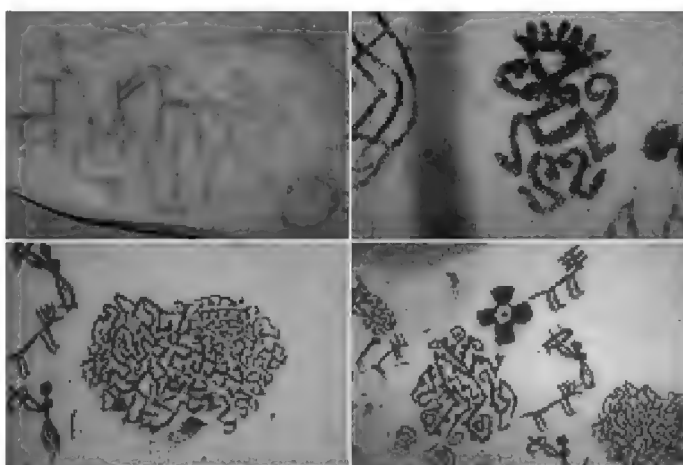
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**Keywords:** Inspection Robot, Planar Map Construction, 3D Reconstruction

## 1. INTRODUCTION

In Southern Italy, along the Adriatic coast, a cave, named “Grotta dei Cervi”, holds a pre-historical treasure, remarkable for its complexity, and artistic and historical relevance. The cave has on its walls a huge collection of paintings of hunting scenes, stags, men, and small animal groups, realized with red ochre and bat guano, dated to the Middle Neolithic period (see Figure 1). The access to the cave is restricted to a few authorized people. Care must be taken to guarantee their safety and to prevent polluting elements from being introduced in this particular and valuable environment. The application of a technological solution seems to be the best way to allow remote access to the archaeological site, thus satisfying the need for cave preservation and safety.

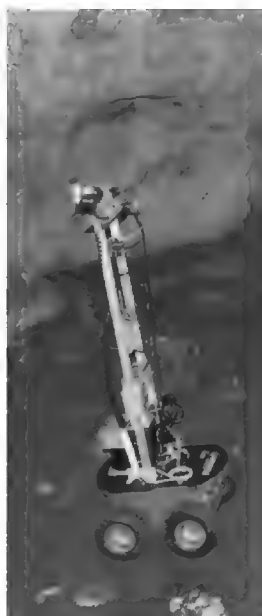
In this paper, we describe the use of a mobile robot, to navigate inside the cave and to acquire useful data by means of the on-board sensors. This solution reduces the risk of damaging the cave because it does not require the installation of invasive infrastructures. The cave is formed by a series of narrow and twisting corridors. We have inspected one of these corridors. The robot is able to construct the 2D map of the environment using a laser range scanner, and to build the 3D model of some zones of particular interest using a computer vision technique. The combination of 2D and 3D reconstruction techniques allows one to obtain a complete knowledge of the environment in an automatic way.



**Figure 1:** Some paintings on the walls of the cave.

Several approaches can be found in literature that deal with the two different problems of building 2D and 3D models of an environment separately. Few works combine the two different tasks. In [1] a mobile robot, equipped with a laser range scanner and a panoramic camera, is used as a security guard to survey large areas; then, a 3D complete model of the environment is reconstructed. In [2] sonar and video data are used for the 3D reconstruction of an indoor environment.

Our aim was to build a robot able to navigate in the site and to reconstruct 3D models of particular areas for the remote fruition of the site, at a lower computational cost and with higher accuracy. Since the explored environment was very particular, several difficulties had to be addressed during the experimental session.



**Figure 2.** The robot navigating in the “Grotta dei Cervi” cave.

## 2. THE MULTI-SENSOR MOBILE ROBOT

The mobile vehicle used for the experimental session is composed of the mobile robotic platform Pioneer P3-AT by Mobile Robots Inc., equipped with a laser range finder, sonar sensors, a video camera, inclinometers, encoders, a compass and an antenna for the wireless communication between the robot and a remote computer (see Figure 2). Its four tractor wheels can scale a 45° gradient and sills of 9cm. Sixteen forward and rear sonar sensors sense obstacles up to 7m away. The laser range finder is able to sense objects at a distance up to 80m away with a resolution of 0.5° (360 readings on 180°).

On the vehicle a support with appropriate height is placed, carrying the illumination system and a pan-tilt-zoom camera. The structure is of aluminium, and is light and robust. It is 1m high in order to acquire the wall paintings from an appropriate perspective. In fact, the most interesting wall paintings are between 1m and 2m above the ground. The laser and video data are used to construct the 2D map of the explored corridor of the cave, and the 3D model of some zones of particular artistic and historical interest, respectively.

First, the planar map of the inspected environment is obtained using the laser scanner mounted on the robot platform and applying a scan matching algorithm. The high accuracy of about one millimeter error allows one to build a very accurate planar map. Using a computer vision technique we can also build the three-dimensional model of some zones of particular

interest. The only geometrical constraint is the correspondence between each feature point in different images. The images must be acquired by the same camera with a fixed focal length.

## 3. PLANAR MAP CONSTRUCTION

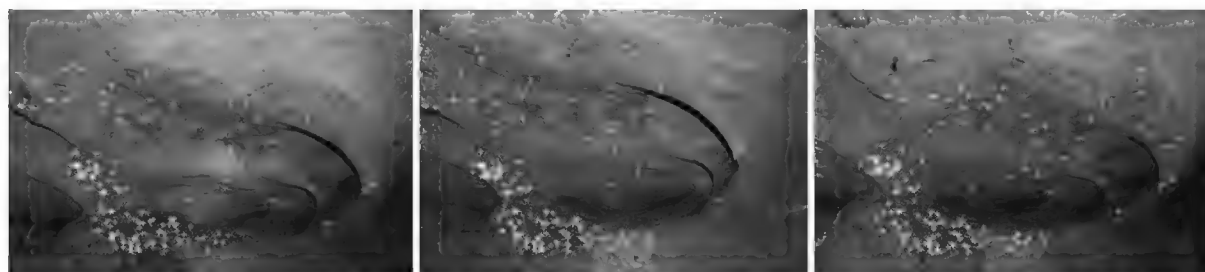


**Figure 3:** 2D map of the explored area of the cave obtained after the application of the scan-matching algorithm.

Mobile robot localization and environment mapping have been extensively studied in the robotics literature [3, 4, 5]. Several researchers have focused on the problem of Simultaneous Localization And Mapping (SLAM), in which a map of the environment is built and the robot is localised therein, simultaneously [6, 7, 8]. Most approaches use precise distance sensors, such as laser range finders [8, 9] for their high accuracy, but often the applicability is restricted to planar structured environments, such as offices and regular buildings. The laser readings have a high accuracy allowing the building of accurate planar maps especially when the robot moves in a plane.

The cave environment presents a very rough terrain characterized by depressions and bumps. In this case, the laser data, that supply planar information, must be integrated with the data from the inclinometer in order to obtain accurate information about the scanned environment. During the data acquisition procedure, the incremental errors typical of odometers must be considered and accounted for. To solve the simultaneous localization and mapping (SLAM) problem, the scan matching algorithm proposed by Gutmann [10] was used. Gutmann algorithm, which is the Combined Scan Matcher (CSM), is based on the integration of the IDC algorithm proposed by Lu and Milios [4] and the one proposed by Cox [11]. Initially the CSM algorithm was tested in our laboratory in order to verify its accuracy. A map of the laboratory was constructed and an error analysis of the

robot position in the map was carried out. This error analysis was done in our lab, because the limited access to the cave prevented us from placing all the necessary instruments into the site. The corrected positions of the robot obtained after the application of the CSM were compared with the robot positions measured by using a theodolite



**Figure 4:** Three images of an area of the wall rich in paintings. The white crosses represent the correct point matches.

station. The estimated error on robot positions was below 30cm. Note that in a robot navigation context this error can be considered negligible, since the estimated position remains inside the robot base.

The CSM algorithm was also applied to the data acquired in the cave obtaining a point map. The corrected planar map is shown in Figure 3, where four zones of particular interest, due to the presence of pre-historical paintings, are also highlighted.

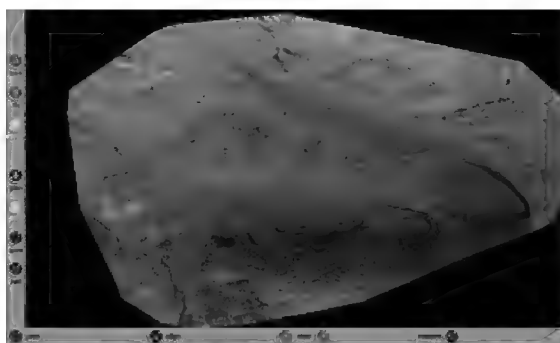
The map obtained using the laser scanner supplies new and useful, although still approximate, information about the structure of the cave: such information was not available before our visit. It is important to note that the structure of the cave, supplied by the map, is very important for the knowledge and the fruition of the archaeological site, since it describes the morphology of the whole environment placing each painting inside its context and facilitating a better understanding of its role and meaning. Furthermore, the planar map is useful for the navigation of the robot inside the cave.

#### 4. 3D MODEL RECONSTRUCTION

Construction of 3D models from images, in the context of mobile robots exploring real indoor environments, is a thoroughly investigated topic in computer vision [1, 7, 12]. The major limitation for extensive use of vision sensors is their computational complexity. However, this problem is becoming less relevant with the increase in computing power of the available machines; therefore, the extraction of real-time full 3D information from cameras seems to be achievable in the near future.

Reconstructing 3D models using computer vision techniques generally requires the extraction of features (e.g., points, lines, target objects), and to match them [1, 13]. Moreover, it is important to determine the correspondence between features in different images since the accuracy of the resulting model depends directly on the accuracy of the feature correspondence. The method described in this paper uses as geometrical constraint only the correspondence between corners in different images.

A complex 3D scene is reconstructed using a set of three images acquired from three different viewpoints of the same scene. The only requirement is that the images must be acquired by the same camera with a fixed focal length.



**Figure 5:** 3D model of the area of the cave pictured in the images of Figure 4.

After image acquisition, feature points that correspond to high curvature points (corners), are extracted in each image using the Harris corner detector. The maximum number of corners to be extracted in each image is fixed a priori. A matching procedure is then applied to each couple of images. A classical correlation technique is, first, used to establish the matching candidates between two images by determining a correlation score for each couple of points. If the correlation score is higher than a given threshold, the related couple of points is considered as a candidate match. To verify the candidate matches, a parameter counts the number of similar candidate matches found in the neighbourhood of each candidate matched point. The sum of these

parameters for all candidate matches defines an energy function. The minimization of the energy function through a relaxation technique solves the ambiguity problem [14]. After the determination of the corner correspondence for each couple of images, the set of correct matches for all the three images is determined.

Figure 4 shows the three images with the matched points. Knowing the corresponding corners, it is possible to determine the Fundamental Matrix and the intrinsic parameters of the camera [15]. At this point, all the necessary data to reconstruct the 3D scene are known. The 3D model is reconstructed through the application of the polygonal mesh technique. The 3D model of the scene has been made by using the VRML. Figure 5 shows the 3D model of the scene acquired in the cave.



## 5. CONCLUSIONS

This work focuses on a technological solution for the remote fruition of paintings in the “Grotta dei Cervi” cave, located in Southern Italy, which is inaccessible to all but the most expert speleologists. A properly equipped mobile robot platform was used to reach this goal. The robot could navigate the cave, and send useful information to a remote console.

The robot is made up of a mobile robotic platform equipped with a laser range finder, sonar sensors, a video camera, inclinometers, odometers, and a compass. Using all these devices and suitably integrated software modules, it was possible to build the two-dimensional map of the site and to recover the 3D structure of some zones of particular interest. The 2D map was constructed using the data provided by the laser range finder. The three-dimensional structure of zones of particular interest were reconstructed using three images acquired from different viewpoints by the on-board camera which has a fixed focal length.

The proposed approaches were demonstrated to be accurate and flexible. Although there are some structural limits, the technological solution presented seems to be suitable for making an archaeological cave available without damaging it. It allows the growth of knowledge of this kind of site, it supports the study of them, and improves the capability of monitoring and preserving very relevant archaeological treasures.

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## VIRTUAL LIGHT TO RESTORE AND INTERPRET CULTURAL HERITAGE WORKS

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**Keywords:** ICT technologies, restoration, image processing, virtual light

### 1. INTRODUCTION

This applied research project is based on the dialectics existing between the coming to light of a newborn artistic creation and its returning to light through its restoration. The main idea is to build a bridge between the metaphysics of the creative thought of the artist and today's vision of the architect/historian of art who performs the restoration. It seems therefore natural to look at the light as the key to enable the interpretation of the work of art and use such light to understand and restore it.

It is known that in every culture, the monument designer is inspired by natural laws. In particular the sun plays a central role, both for the man's mind and his creation. Hence the relationship with light is, in general, a designing principle for the monument. Every restoration program should be based on the reconstruction of such relationship.

To this aim, we will employ the most recent available technologies for the simulation of light sources and their relative effects on a work of art.

It was our purpose to conceive artificial light conditions that would help the restoration designer and the supervisor responsible for the work, to better understand the creative idea which inspired the author of the monument, even when the monument itself presents some difficulties to be directly inspected, as for frescoes and ornaments that are either in remote places (as church ceilings), or can only be partly looked at because inaccessible or substantially damaged during the centuries. Computer programs have greatly facilitated new techniques to help us in this direction.

The use of virtual light in our approach was intended to provide an interactive facility so as to change point of view, illumination features and time conditions (for any hour of any day of the year, etc.). Next we have also specifically considered how a given pictorial element (pixel), seen from an observer looking at a decorated wall, reflects light and its chromatic properties. In our approach we wanted to balance the computational weight with the credibility of the visual result.

In this paper we restrict ourselves to the description of the inner workings required to achieve a simulated 3D effect starting from 2D information. In fact, each and single element taken by a digital camera was processed according to special algorithms for simulating a three-dimensional representation of the original two-dimensional picture. These algorithms belong to a large family of small-scale detail representation that we collectively call *bump mapping*.

As an example of such an approach we will consider the digital reconstruction of a roman church (Sant'Agnese in Agone, Rome, Italy), restricting ourselves to the problem of the three-dimensional rendering of the decorations found on one of the main arcs. More specifically, we will focus on one flower decoration, which is multiply reproduced in the arc, not necessarily in identical versions. For this reason we were interested in developing fast and simple methods for simulating a three-dimensional representation that would help the art historian in his interpretation, as well as an observer that does not have direct access to the physical decoration.

### 2. THE APPROACH

The used method is based on the superposition, on the original digital image of the decoration, of a number of images computed through suitable algorithms.

The basic starting point is the notion of "geometric normal" associated to each pixel of the image: if we think about a horizontal plane upon which we superimpose our original photo of the flower decoration, the geometric normal of each pixel in the plane will be vertical (exiting from the plane). At this point the shading equation (which is responsible for calculating the final color of each pixel in a real-time rendering system) will have no information about the geometry of the flower decoration, and the final effect is quite "flat", as if we are lighting up a painted plane (fig. 1).

The lack of 3D perception in fig.1 is caused by the geometric normals values: they are perpendicular to the plane for each pixel, which is just the mathematical representation of a flat plane. Our intent is to alter per-pixel normal so as to match the surface geometry of the relief we want to simulate. We can do that using a particular texture named normal map (fig. 2) [1]. For each pixel, the normal map encodes a new normal value, which will replace its geometric normal. Now, the shading equation knows how to light up correctly each pixel so as to match light position and the normal map mathematical surface description. In fig. 3, the light is positioned in the bottom-right of the scene, and the surface is lighted up as if the flower decoration was in relief.

In addition to that, we can retrieve per-pixel information about: **ambient occlusion** (occlusion map, fig. 4), so as to simulate light absence wherever indentations are narrow and light cannot easily penetrate; **specular component of the light equation** (specular map) (fig. 5), either for its intensity or for its colour, so as to enhance the golden coloured pixels whilst diminishing the light values of dark coloured pixels to provide information on specific physical components. All this new information is used in the light equation to enhance the third dimension perception of the ornament (fig.6) [2, 3].

The next step is to estimate the depth for every pixel by calculating the height map (fig. 7). Now we can improve the depth perception of the surface and add shadows in our scene, so as to dramatically increase the third dimension perception [4].

The final figure shows the resulting image after applying our virtual illumination approach based on the superposition of specific computed images (fig. 8).

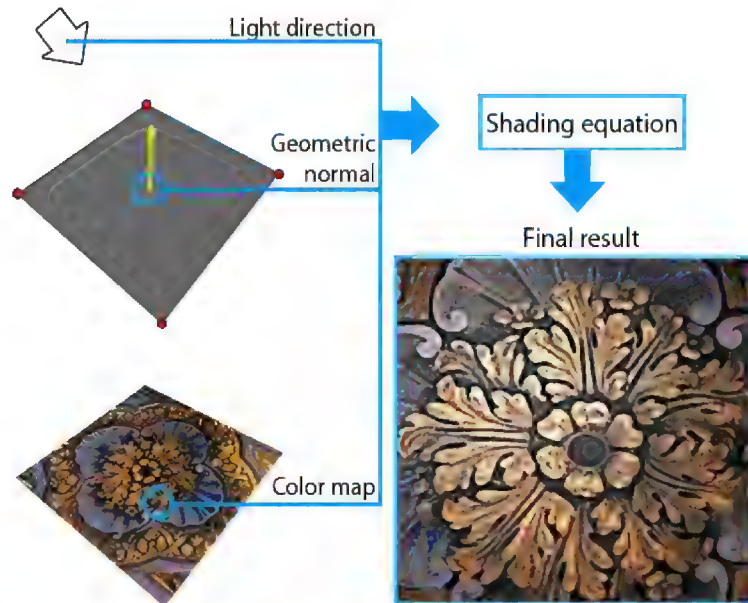


Figure 1 - Every pixel on the surface has the same geometric normal, which is perpendicular and pointing out from the plane. As a result, the final effect is quite “flat”.

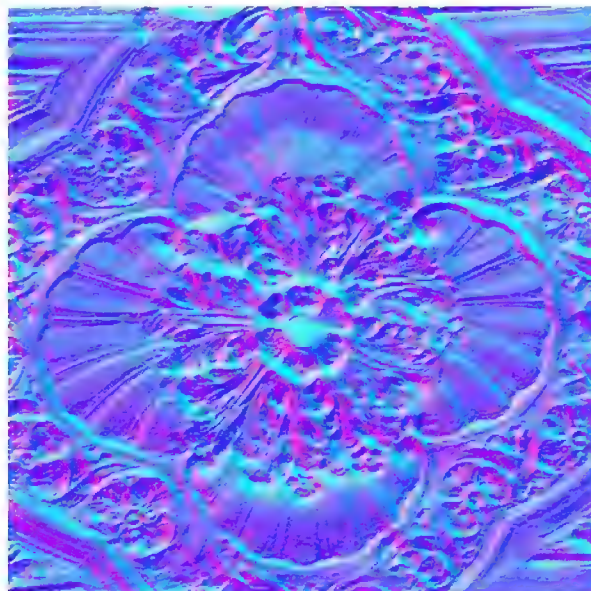


Figure 2 - The normal map obtained by encoding each vector component for every pixel, via R, G, B values.

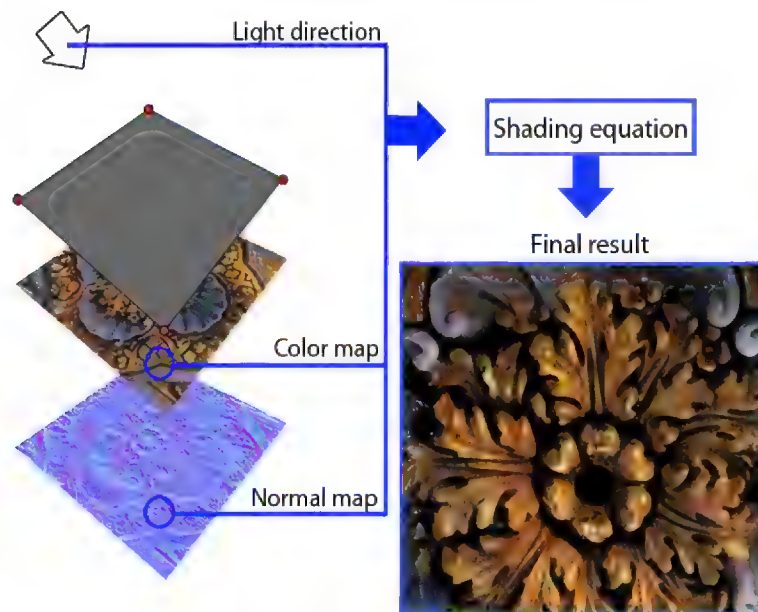


Figure 3 - By overlaying the normal map, the shading equation retrieves per-pixel color intensity from the light direction and per-pixel normal value from the normal map

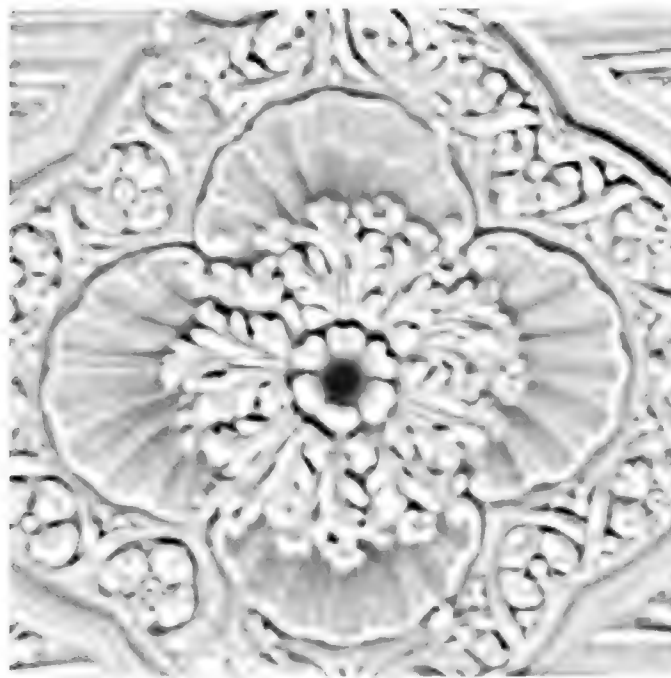


Figure 4 - The occlusion map: darker areas decrease the weight of the diffuse light component.





Figure 5 - The specular map: darker areas decrease the weight of the specular component; colours are also affected

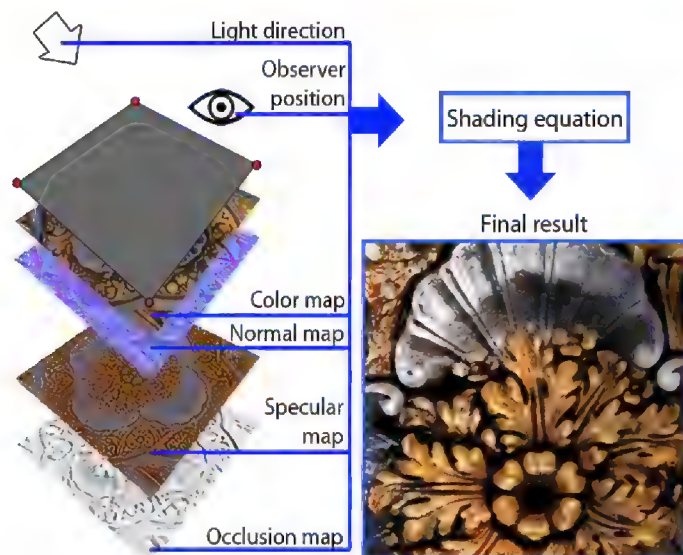


Figure 6 - The specular and the occlusion maps enhance the 3D perception of the surface. Note that now the shading equation needs to know the position of the observer, to calculate if the specular gloss is visible.

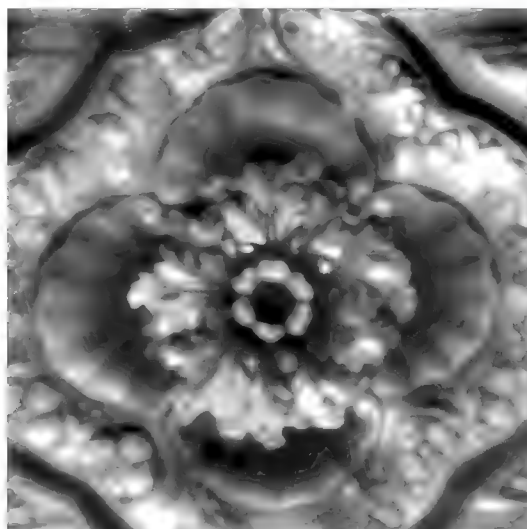


Figure 7 - The height map: darker areas are deeper than lighter ones.



Figure 8 - The addition of height map information: notice how the shadows on the shell surrounding the flower radically increase the third dimension perception.

### 3. CONCLUSION

In this paper we have only shown a small sample of the enormous possibilities that virtual illumination can play in the field of cultural heritage. In fact, within an architectural study of a work of art, we may obtain, besides a facilitation of the interpretation, restoration guidelines, hints for designing artificial light setups, suggestions for reusing such work of art and facilities for a pedagogical and tourist exploitation.

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## A WIRELESS SENSORS NETWORK FOR THE ENVIRONMENTAL MONITORING OF A SAVOY RESIDENCE IN ITALY

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### Abstract

A system for microclimate monitoring, able to satisfy the requirements for application in heritage buildings, has been developed. The system is composed of a wireless network of extremely compact sensors for temperature and relative humidity measurements. The system has been validated in laboratory and is currently being used for an in situ measurement campaign inside a Savoy residence in Turin (Italy).

The rooms of this residence are decorated with precious wood paneling, portraits and several tin-mercury mirrors. The tin-mercury amalgam is fundamentally unstable but, although it is impossible to prevent the degradation and the release of liquid mercury in the environment, the reaction may be slowed down by keeping the mirrors at low and constant temperature and by avoiding exposing them to high relative humidity and temperature excursions.

The data collected in the experimental measurements campaign are particularly important not only to preserve the artefacts, but also to highlight in real time potentially unsafe conditions for staff and visitors of the building due to the presence of toxic mercury vapours in the atmosphere.

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**Keywords:** wireless network, temperature sensors, humidity sensors, tin-mercury mirrors

### 1. THE VILLA DELLA REGINA

The *Villa della Regina* in Turin is one of the Piedmont Residences of the Royal House of Savoy listed by UNESCO as a World Heritage site, Fig. 1.

The “*Villa della Regina*” is a building, garden and vineyard complex which was built on the Turin hills at the beginning of the seventeenth century by Cardinal Maurizio of Savoy, son of Duke Carlo Emanuele I, on the model of the ancient Roman villas. In 1657 his wife, Ludovica, began the work of enlarging the buildings and gardens and updating the furnishing and decoration.

In accordance with Ludovica's will, in 1692 the Vineyard passed to Anna D'Orléans, wife of Duke Vittorio Amedeo II, who brought many important changes to what from then onwards would be called *Villa della Regina*. Under the direction of the architects Filippo Juvarra and Giovanni Pietro Baroni di Tavigliano the *Villa* area and its relationship with the garden was redefined. The furnishings and decorations were modernized by court painters such as Daniel Seiter and Claudio Francesco Beaumont and by teams of stucco workers. Juvarra then brought in and directed the most important artists then working in the capital of the kingdom: Giovanni Battista Crosato, Corrado Giaquinto, Giuseppe Dallamano, Giuseppe Valeriani, Filippo Minei, Giovanni Battista Fariano and Pietro Massa and their workshops [1-3].

The unitary character of the vineyard complex was maintained from the initial project, with the *Villa* at the centre of the Italian Gardens, courtly pavilions, grottos, fountains, vegetable gardens, woods and vineyards; it was preserved even after it ceased to be a royal country estate in 1868, when Vittorio Emanuele II granted the property to the Istituto Nazionale per le Figlie dei Militari Italiani [4,5].

In the twentieth century the condition of the complex was compromised because of partial demolitions, war damages and inappropriate restoration and conservation activities. The closure of the Institute in 1975 left buildings and gardens deserted, leading to a state of deterioration that the sporadic works of intervention performed in the 1980s were unable to contrast. The whole estate was soon forgotten and physically cancelled from view from the city, overgrown with vegetation and impracticable because of the worsening condition of the buildings, of the decorations and of the gardens, gradually bringing the complex to the verge of collapse.

In 1994 the *Villa* was entrusted to the *Ministero per i Beni Culturali ed Ambientali*, *Soprintendenza per i Beni Storici, Artistici ed Etnoantropologici del Piemonte*, that drew up the General Project for the restoration and reutilization of the complex subsequently approved in 1997.

Thanks to the architectural, artistic and botanic restoration works, the *Villa* and its gardens have recovered their previous splendour [6-10]. The *Villa della Regina* is once more the backdrop of Turin south of the river Po according to the original sixteenth and seventeenth century projects and, since 2006, it is open for the public to visit.





Figure 1 – The façade of the *Villa della Regina*

## 2. THE RESTORATION CAMPAIGN

### 2.1. The building and the gardens

The restoration campaign carried out from 1997 to 2009 led to the recovery of the building itself, together with its moveable assets, paintings, mirrors and furnishings and of the external areas, both of great interest from an historical and artistic point of view.

As a matter of fact, a double curvilinear staircase with central fountain leads to the portico entrance: two side pavilions give light to the façade, crowned in the centre by a terrace with statues. Inside there are frescoes and paintings by Giovanni Battista Crosato, Daniel Seyter and Corrado Giaquinto in the main room, grotesques of Filippo Minei and paintings by the brothers Domenico and Giuseppe Valeriani in the near rooms; there are also precious *Chinese Cabinets* in lacquer and golden wood, Fig. 2.



Figure 2 – Interior of the *Villa della Regina*

The restoration has been completed by the recovery of the extraordinary "*Teatro delle Acque*", consisting of springs, fountains and fish tanks, architectural and decorative equipments, Fig. 3.





**Figure 3** – The “*Teatro delle acque*” of the *Villa della Regina*, after the restoration work

## 2.2 The tin-mercury mirrors

Several rooms of the *Villa della Regina* are decorated with wood panelling and glasses backed with a tin–mercury alloy, commonly called the amalgam mirrors, which were the dominant mirrors used from the 15<sup>th</sup> century until the beginning of the 20<sup>th</sup> century. Most of these mirrors show small dark patches that give a dark and cloudy appearance to the degraded areas; when the degradation process proceeds, the blackish layer formed becomes quickly incoherent leading to the complete loss of the reflectiveness.

In order to clarify the corrosion mechanism, microchemical, micromorphological and microstructural analyses of the alloy surface and of the degradation products of some mirrors have been carried out by scanning electron microscopy (SEM) equipped with energy dispersive X-ray spectrometry (EDX) and by X-ray diffraction (XRD).

The characterization results indicated that the amalgam is composed of a binary alloy of tin and mercury ( $\text{Hg}_{0.1}\text{Sn}_{0.9}$ ), that holds a thin layer of liquid mercury in contact with the glass as a reflective coating. Mercury is volatile and slowly evaporates, leaving finely divided particles of tin that are easily oxidized, forming romarchite ( $\text{SnO}$ ) and cassiterite ( $\text{SnO}_2$ ) [11].

Tin-mercury mirrors are very difficult to be preserved because the amalgam is thermodynamically unstable and it is impossible to stop the corrosion process. For this reason a restoration method based on an amalgam inlay produced *in-situ* on the corroded zone of the mirrors has been applied on the mirror shown in Fig.4; the aesthetic appearance is satisfactory and the restoration methodology will be extended to other mirrors.

The presence of the tin-mercury mirrors may cause in the building potentially unsafe conditions for staff and visitors, if the degradation rate increases with the consequent release of mercury vapours in the environment. As a matter of fact, according to the Italian law, the Threshold Limit Value (TLV) for mercury in indoor environments is of about  $25 \mu\text{g}/\text{m}^3$  i.e. less than 1.6 ppm for prolonged expositions.

The amalgam degradation phenomenon can be slowed down only by keeping the artefacts in controlled microclimatic conditions, so a monitoring campaign of the environmental parameters is going on in the *Villa della Regina*.

The monitoring system developed for this study is based on a wireless network of extremely small sensors, which after being characterised in laboratory from the metrological point of view, have been positioned in the *Villa* in order to acquire enough data to help curators to build-up a proper environmental control system.



**Figure 4** – Tin-mercury mirror of the *Villa della Regina*

### 3. THE MONITORING CAMPAIGN

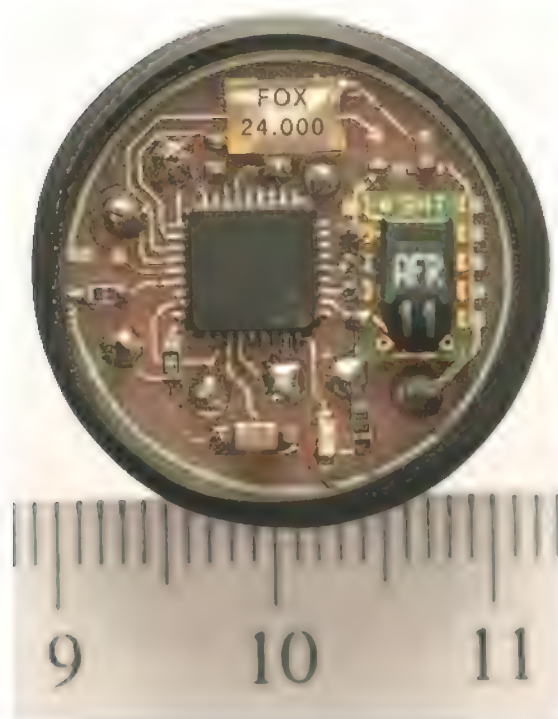
#### 3.1 The button-like sensors network

The proposed sensors network has been arranged to fit specific requirements for use in historical buildings. The sensors have been designed in form of buttons (2 cm in diameter), as shown in Fig. 5. The key advantage over traditional systems is the very compact dimension, which allows the buttons to be installed essentially unnoticed even very close the artefact to be preserved.

The buttons embed an SHT11 sensor by *Sensirion*, designed to perform measurements in the range  $-40$  to  $+80^{\circ}\text{C}$  with an uncertainty of  $\pm 2^{\circ}\text{C}$ , and in the range of 10% to 90% with about 3% of absolute uncertainty. Thanks to a very low power architecture [13], each button can work unmanned for a few years with a common lithium button battery. Moreover, the sensors are based on the system build on chip (SoC) CC2510F32 (by *Texas Instruments*), which embeds the CC2500 RF radio, an enhanced 8051 microcontroller with several power-save sleep modes, 32 KB of flash memory and 4 KB of RAM memory.

The sensors are configured to send the measurements by means of radio signals within the ISM band (2.400÷2.483 GHz frequency range) to a base station, which is the receiver that collects all the data. The base station can be connected either directly to a PC or to the Internet by means of either a Local Area Network (LAN) or a GPRS modem, so that the measurements can be retrieved either periodically or in real-time from a remote computer. In the first case, the sensors switch on only to perform the measurements that are stored inside the embedded memory, in the second case the data can be collected and processed continuously. The sensors turn on the radio only when data have to be sent to the base station to be collected and processed. If required, a reconfiguration of the measurement and communication strategies can also be performed by means of the radio, when the link is established during the data transmission.



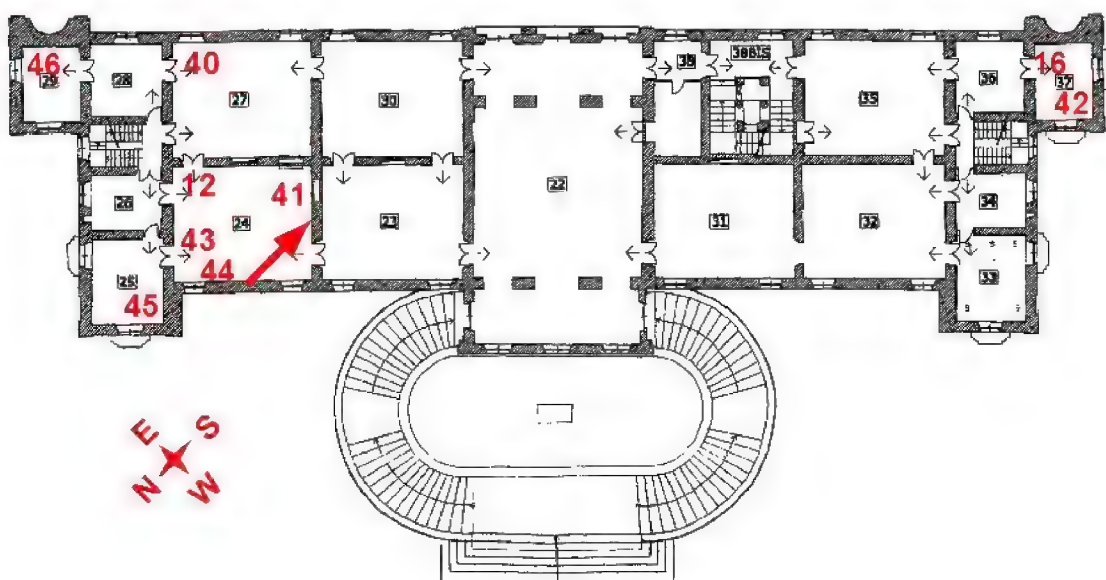


**Figure 5** – A button-like sensor for T and RH measurements

### 3.2 Results and discussion

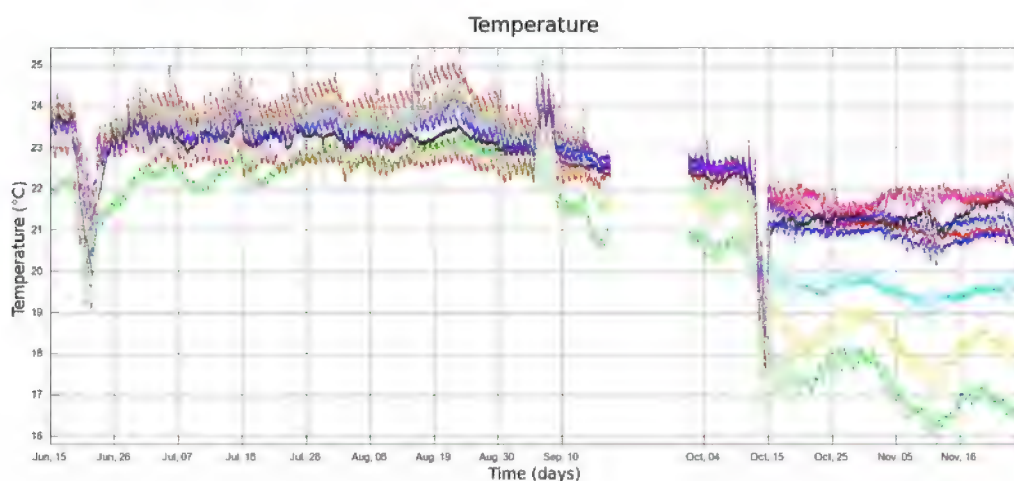
An experimental campaign of in situ measurements is currently in progress in the *Villa della Regina*. The aim of this experimental campaign is both to validate the sensors network architecture, as well as to highlight in real time abnormal temperature and humidity excursions that can be dangerous for the artefacts stored inside the building.

Nine button-like sensors have been positioned in five rooms, numbered 24, 25, 27, 29 and 37 in the map of Fig.6. They have been configured to perform temperature and humidity measurements every 20 min. Thanks to their small dimensions and the radio link, some buttons were directly positioned in contact with the wood panels that support the mirrors or on the walls behind them, thus allowing to monitor the microclimate nearby the items.

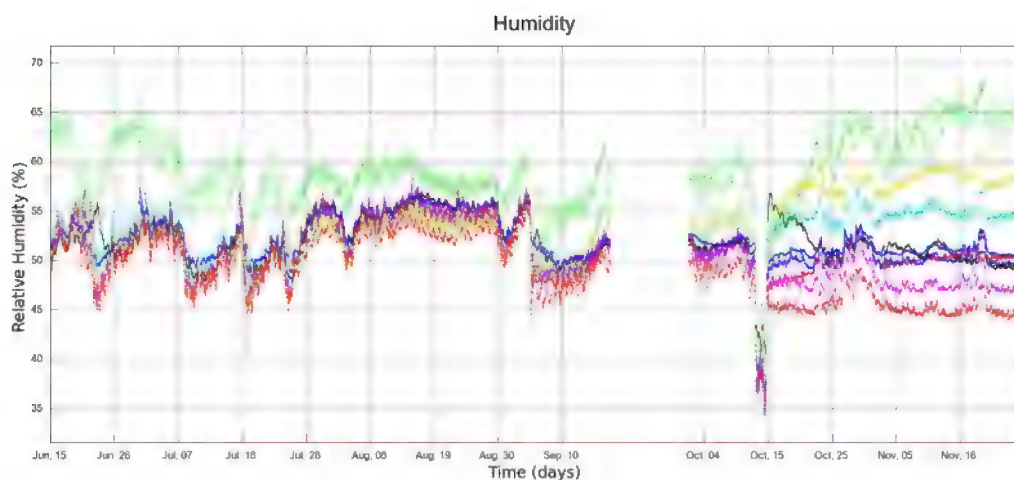


**Figure 6** – Map of the Villa, with the indication of the sensors position

As an example, the data collected by seven sensors, numbered 40, 41, 42, 43, 44, 45 and 46, in the first eight months of the experimental campaign are shown in Fig. 7 and Fig. 8.



**Figure 7** – Temperature trends monitored in the *Villa della Regina* from June 2009 to January 2010. From top to bottom sensor 40, 41, 42, 43, 44, 45 and 46



**Figure 8** –Relative humidity trends monitored in the *Villa della Regina* from June 2009 to January 2010. From top to bottom sensor 46, 45, 44, 43, 42, 41 and 40

All sensors detected a noticeable temperature excursion in the first seven days of the monitoring campaign. This excursion, observed during the summer, can be probably correlated to problems in the control of the building air conditioning system. After these few days, the temperature values measured were correctly maintained in the range of  $\pm 3^{\circ}\text{C}$ , around an average temperature of  $24^{\circ}\text{C}$ . The lower temperature was only measured by the sensor n. 46, positioned on the floor of room 29.

During winter, the situation is quite different; the values are spread in a wider range. In particular the sensors n. 44, 45 and 46 positioned in the rooms exposed to North, directly in contact with the perimetral wall, during the last two months of the measurements campaign (from 12<sup>th</sup> December to 6<sup>th</sup> January) measure temperatures till six degrees lower with respect to the other areas, thus evidencing problems related to the air conditioning system.

Concerning the relative humidity, all the sensors detected a relative humidity change in the range of 10% during the entire monitored period. In particular, sensors n. 44, 45 and 46, which have been positioned in the rooms exposed to North, measured high relative humidity values, which remained higher than 50% for almost the entire period. In this area of the *Villa* percolation of rain water phenomena have been observed behind the wood panelling that cover the walls.

The positioning of the button sensors allowed to highlight microclimate changes with a very short delay. Furthermore, in agreement with the restorers, the high relative humidity, with peak values of 70%, has been identified as the environmental parameter that mainly affects the conservation conditions both of the tin-mercury mirrors and of the furniture displayed inside the building.



#### 4. CONCLUSIONS

In this work a wireless network of button-like sensors for the monitoring of thermo-hygrometry parameters in heritage buildings has been described.

The experimental monitoring campaign in the *Villa della Regina* is currently in progress, however, the results of the preliminary tests over the first eight months show the advantages of the proposed solution that is really suitable for application in the field of cultural heritage conservation.

In the next future, some buttons will be integrated with new sensors for different chemical-physical quantities (i.e. Hg vapors).

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## CALTAGIRONE . STEPS OF SANTA MARIA DEL MONTE – PERMANENT ILLUMINATION

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The monumental stairway, declared a World Heritage site recently by Unesco, was built in the 17<sup>th</sup> century to fulfil an important town-planning function, namely to connect the higher level of the city — the centre of religious authority, symbolized by the old Church of the Madrice — and the lower level, the seat of civil authority revolving around the Palazzo Senatorio. (image 1)



**Figure 1** - Steps of S. Maria del Monte - Caltagirone - Day view

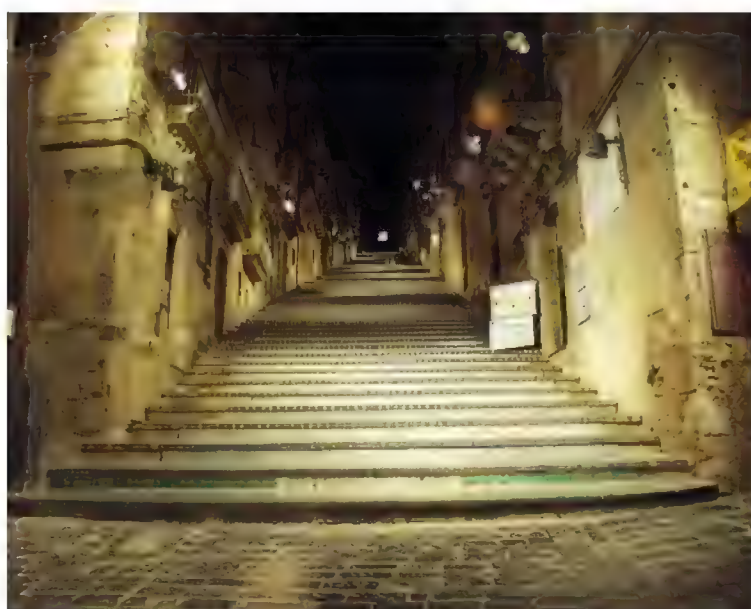
The steps as they appear today, with majolica-tiled risers and lava stone treads, are the work of local artist Antonino Ragona, who in 1954 created the 142 risers (all different, with no duplications), incorporating decorations that reflect the ceramic tradition of Caltagirone, with Sicilian, Arab, Norman and Spanish influences.

It soon became clear that the lighting design would be a complex undertaking, given the unique nature of the task. It was not possible to shape clear objectives without detailed knowledge of the stairway, its architecture, and the urban setting it occupies. In effect, the steps of S Maria del Monte play an important environmental role as an unmistakable legacy of 17<sup>th</sup> century Sicilian town planning, of which the strongest and most common element is the crossroads. (image 2)



**Figure 2** - Steps of S. Maria del Monte – Caltagirone - Lighting project

Comparing the two elevations, it was clear that the placement of the light sources had to be studied individually, for each single luminaire, and that there would be little chance of achieving a uniform rhythm in the installations. Having looked at the overall picture, the design objectives were identified and set. The lighting had to deliver high quality, both visually and technically: superior colour rendering and high levels of illuminance on vertical surfaces, **(image 3)** steps floodlit non-uniformly to accentuate their depth, visibility of the junctions with side alleys to place the monument in its urban context, absence of glare and minimal visual impact of the fixtures utilized, not to mention ease of installation and maintenance. **(image 4)**



**Figure 3** - Steps of S. Maria del Monte - Caltagirone

At an opening ceremony on 22 July 2003, the Scala S Maria del Monte became a “naturally luminous” vertical ribbon of light connecting the two levels of the city. **(image 5)**





**Figure 4** - Steps of S. Maria del Monte - Caltagirone - General night view



**Figure 5** - Steps of S. Maria del Monte - Caltagirone - Night view



## THE ENERGY COST OF THE INDOOR CLIMATE QUALITY IN MUSEUMS: THE “GREEN MUSEUM” CHALLENGE

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### Abstract

Indoor climatic control is a crucial aspect for artefacts conservation in museum environments to prevent damages. Last years development of technologies and equipments aimed at continuous monitoring the indoor environmental parameters (temperature, relative humidity, air speed, lighting, air pollutants, etc.) allowed the collection, elaboration and analysis of indoor environmental data in order to avoid any deterioration processes on works of art: preventive control programmes are nowadays widely applied in museums. Anyway, what is the energy price we have to pay to maintain a strict mechanical indoor climatic control in museum? Is it really necessary to keep the indoor climatic parameters within a narrow range? These are key questions because also museums have to face with:

- energy issues, where the goal is a rational use of energy sources and an increasing application of renewable sources
- environmental issues, where the goal is a reduction of CO<sub>2</sub> emission
- economical issues, where the goal is to reduce the impact of energy costs.

Nevertheless, in museums these goals have to be achieved without compromising preservation aspects: that's the way to follow for a new target for museums, the “green museum”.

The study will present investigations aimed at highlighting the relationship between indoor environmental quality level in museums, as defined by ASHRAE Applications Handbook [2] and Italian Standard UNI 10829/1999 [1], and the energy and environmental costs necessary to provide the required indoor environmental quality level, analysing different thermo-physical characteristics of the building envelope and different HVAC system solutions.

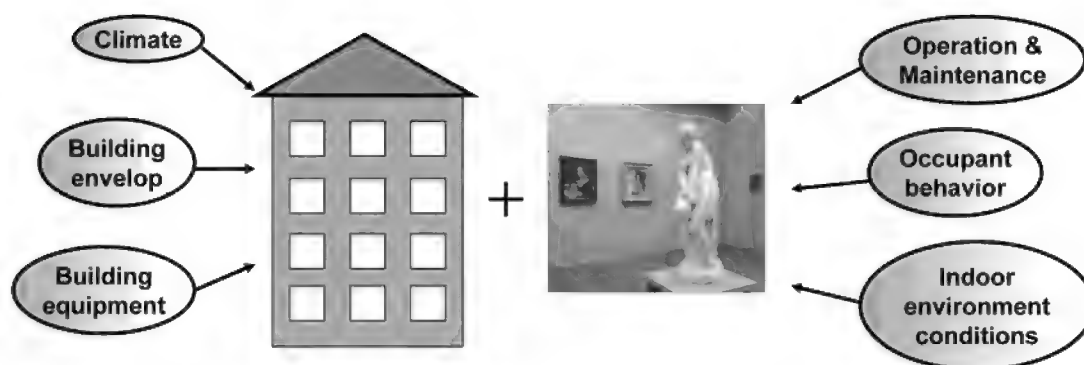
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### INTRODUCTION

Works of art require the maintenance of specific air temperature (T) and relative humidity (RH) values for their optimal preservation. When the artefacts are placed in exhibition rooms or in warehouses, the maintenance of expected air temperature and relative humidity values depends on the characteristics and potentials of the “building-HVAC” system to control the indoor climate (air temperature, relative humidity, and quality). In fact, after defining the acceptable interval of T and RH for artefacts preservation, it is necessary to verify if the museum has a thermo-hygrometric control potential able to fulfil the desired conditions. The thermo-hygrometric control potential depends on the combined actions of passive and active control systems, respectively linked to the building envelope behaviour and to the air-conditioning characteristics. Obviously, the use of an active system leads to an important consequence: energy consumption, environmental impact through CO<sub>2</sub> emissions and consequent costs. Therefore, it is evident that as more punctual the thermo-hygrometric control demands are, the more “shielded” the environment will have to be against surrounding factors which may affect the indoor climate.

In particular, the recent project of the International Energy Agency IEA-ECBCS Annex 53 “Total energy use in buildings” focuses six main factors influencing the building energy uses (see figure 1): one factor is connected to the site (climate), two factors are strictly connected to building design (envelope and equipments) and three factors are related to the building actual operating conditions, including required indoor climate and human behaviour.

Over the last years, there has been an increasing interest about “Indoor environmental conditions” in museums. Italian Standard UNI 10829/1999 “Beni di interesse storico e artistico. Condizioni ambientali di conservazione. Misurazione ed analisi” [1] defines the guidelines for indoor climate parameters monitoring for preservation purposes and, in its Appendix A, suggests for such parameters some acceptability intervals to be used as a reference for the analysis of different kinds of works of art. As an example, the reference values for acceptability intervals (air temperature and relative humidity) of some works of art according to Italian Standard UNI 10829 are shown in table 1.



**Fig. 1.** Total energy use in buildings: six influencing factors by IEA-ECBCS Annex 53.

**Table 1.** Temperature and relative humidity acceptability interval for some works of art according to the Italian Standard UNI10829 [1].

Works of art	Air temperature [°C]	Maximum daily temperature fluctuations [°C]	Air relative humidity [%]	Maximum daily relative humidity fluctuations [%]
[...], painted wood, painting on wood, icons, [...]	19 - 24	1.5	50 - 60	4
Painting on canvas [...]	19 - 24	1.5	45 - 60	6
Drawings, watercolour on paper support [...]	19 - 24	1.5	45 - 60	2

The topic of the relationship between indoor climate requirements and potential of indoor climate control is well dealt with by ASHRAE [2]: in particular, in the table 2, the “classes of thermo-hygrometric control” for artefacts preservation are shown, ranging from class AA (very high control) to class D (very poor control). It is evident that ASHRAE moves the attention from the object to the environment: 5 control classes are defined, on the basis of specific sensitivity thresholds (accepted seasonal or short-term fluctuations). The classes of indoor climate control proposed by ASHRAE’s approach, have been compared to the characteristics of different building-HVAC systems, in order to classify the potential indoor climate control in different types of buildings. Table 3 highlights the strong relationship among thermo-physical characteristics of the building envelope, building use and potential/ properties of the system dedicated to indoor climate control.

### GREEN MUSEUM CHALLENGE

Even if few data about actual energy consumptions in museums are shown in the scientific literature, also the museums sector plays a not-negligible rule in primary energy consumption, CO<sub>2</sub> emissions and environmental impact. In the context of sustainable development, museum should be constructed or renovated with adequate preservation conditions, occupant comfort, limited not-renewable resource use and low environmental impact. Referring to the life cycle of a building, it includes energy for material production, construction, operation, maintenance, disassembly and waste management. All these phases have to be considered in order to minimize the life cycle primary energy use and CO<sub>2</sub> emissions.

**Table 2.** *Classes of thermo-hygrometric control for artefacts preservation according to ASHRAE (2007) [2]*

Type	Set Point or Annual Average	Maximum Fluctuations and Gradients in Controlled Spaces			Collection Risks and Benefits
		Class of Control	Short Fluctuations plus Space Gradients	Seasonal Adjustments in System Set Point	
<b>General Museums, Art Galleries, Libraries, and Archives</b>  All reading and retrieval rooms, rooms for storage of chemically stable collections, especially if mechanically medium to high vulnerability.	50% rh (or historic annual average for permanent collections)  Temperature set between 15 and 25°C <i>Note:</i> Rooms intended for loan exhibitions must handle set point specified in loan agreement, typically 50% rh, 21°C, but sometimes 55% or 60% rh).	<b>AA</b> Precision control, no seasonal changes	±5% rh ±2 K	Relative humidity no change Up 5 K; down 5 K	No risk of mechanical damage to most artifacts and paintings. Some metals and minerals may degrade if 50% rh exceeds a critical relative humidity. Chemically unstable objects unusable within decades.
		<b>A</b> Precision control, some gradients or seasonal changes, not both	±5% rh ±2 K	Up 10% rh, down 10% rh Up 5 K; down 10 K	Small risk of mechanical damage to high vulnerability artifacts, no mechanical risk to most artifacts, paintings, photographs, and books. Chemically unstable objects unusable within decades.
			±10% rh ±2 K	RH no change Up 5 K; down 10 K	
		<b>B</b> Precision control, some gradients plus winter temperature setback	±10% rh ±5 K	Up 10%, down 10% rh Up 10 K, but not above 30°C Down as low as necessary to maintain RH control	Moderate risk of mechanical damage to high vulnerability artifacts, tiny risk to most paintings, most photographs, some artifacts, some books and no risk to many artifacts and most books. Chemically unstable objects unusable within decades, less if routinely at 30°C, but cold winter periods will double life.
		<b>C</b> Prevent all high risk extremes	Within 25 to 75% rh year-round Temperature rarely over 30°C, usually below 25°C		High risk of mechanical damage to high vulnerability artifacts, moderate risk to most paintings, most photographs, some artifacts, some books and tiny risk to many artifacts and most books. Chemically unstable objects unusable within decades, less if routinely at 30°C, but cold winter periods will double life.
		<b>D</b> Prevent dampness	Reliably below 75% rh		High risk of sudden or cumulative mechanical damage to most artifacts and paintings due to low humidity fracture; but high-humidity delamination and deformations, especially in veneers, paintings, paper, and photographs, is avoided. Mold growth and rapid corrosion avoided. Chemically unstable objects unusable within decades, less if routinely at 30°C, but cold winter periods will double life.

**Table 3.** *Classification of the potential indoor climate control in different types of buildings.*

Category of Control	Building Class	Typical Building Construction	Typical Type of Building	Typical Building Use	System Used	Practical Limit of Climate Control	Class of Control Possible
Uncontrolled	I	Open structure	Privy, stocks, bridge, sawmill, well	No occupancy, open to viewers all year	No system.	None	D (if benign climate)
	II	Sheathed post and beam	Cabins, barns, sheds, silos, icehouse	No occupancy. Special event access.	Exhaust fans, open windows, supply fans, attic venting. No heat.	Ventilation	C (if benign climate) D (unless damp climate)
Partial control	III	Uninsulated masonry, framed and sided walls, single-glazed windows	Boat, train, lighthouse, rough frame house, forge	Summer tour use. Closed to public in winter. No occupancy.	Low level heat, summer exhaust ventilation, humidistatic heating for winter control.	Heating, ventilating	C (if benign climate) D (unless hot damp climate)
	IV	Heavy masonry or composite walls with plaster. Tight construction, storm windows	Finished house, church, meeting house, store, inn, some office buildings	Staff in isolated rooms, gift shop. Walk-through visitors only. Limited occupancy. No winter use.	Ducted low level heat. Summer cooling, on/off control. DX cooling, some humidification. Reheat capability.	Basic HVAC	B (if benign climate) C (if mild winter) D
Climate controlled	V	Insulated structures, double glazing, vapor retardant, double doors	Purpose built museums, research libraries, galleries, exhibits, storage rooms	Education groups. Good open public facility. Unlimited occupancy.	Ducted heat, cooling, reheat, and humidification with control dead band.	Climate control, often with seasonal drift	AA (if mild winters) A B
	VI	Metal wall construction, interior rooms with sealed walls and controlled occupancy	Vaults, storage rooms, cases	No occupancy. Access by appointment.	Special heating, cooling, and humidity control with precision constant stability control.	Special constant environments	AA A Cool Cold Dry

Figure 2 shows the picture concerning the indoor climatic control during the museum operation phase. Obviously, in order to maintain the desired indoor environment quality in terms of air temperature, air relative humidity, air quality, lighting, etc., a complex system have to deliver energy to the building (see for details Standard EN 15603) [3]. As well as specified in the standard, the *delivered energy* is “energy supplied to the technical building system through the system boundary (inside or outside areas associated with the building where energy is consumed or produced), to satisfy the uses taken into account (heating, cooling, ventilation, hot water, lighting, appliances, etc..) or to produce electricity”. The delivered energy (hot water, cold water, electricity) is supplied by *energy carriers* (natural gas, electricity). Energy carriers derive from the *primary energy*, including non renewable energy and renewable energy (total primary energy). The primary energy is calculated from the amounts of energy carriers, using conversion factors (for example, Italian electricity conversion factor is 2.17 kWh/kWh<sub>e</sub>). Sun, forests, coal mines, petroleum, gas fields and so on are the sources form which useful energy can be extracted or recovered either directly or by means of a conversion or transformation process (*energy sources*).

The energy efficiencies of all these processes (from the indoor environment to the source energy) are significant in determining the total energy consumption of building, both for the operation phase and for the total life cycle. The choice of energy resource is also important, as type of fuel is crucial for the CO<sub>2</sub> emission.

In the simulation presented in the following paragraph, some different combinations of building-HVAC system to control the indoor climate are investigated in order to highlight the relationships between indoor climate quality and related energy consumption and CO<sub>2</sub> emissions.

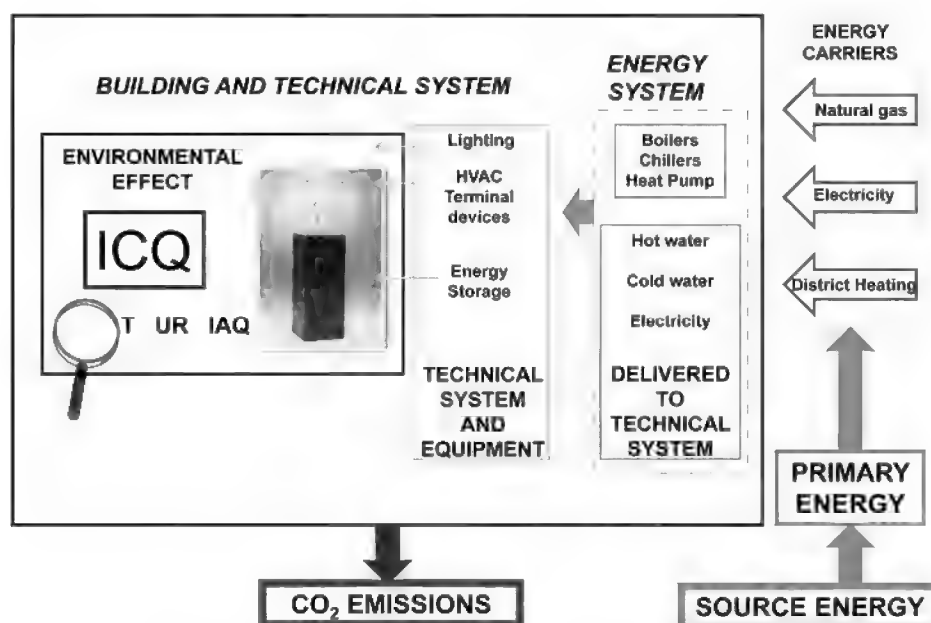


Fig.2. From ICQ to CO<sub>2</sub> emissions: a complex energy path.

## ENERGY SIMULATIONS

The way for a sustainable indoor climatic control is firstly to keep the acceptability intervals as wide as possible according to the specific requests of the artefacts, than to reduce the energy demand by a high performance building envelope and finally to mechanical control the climate by an efficient low-energy HVAC system. The difference among the various strategies to control the indoor climate is therefore evident when the acceptability intervals are matched to the costs to bear in order to reach the defined indoor microclimatic conditions. On the basis of these preliminary remarks, a numerical study aimed at examining the existing relationships among the indoor climate levels requirements, the potential of the “building-HVAC system” control, the energy consumptions and CO<sub>2</sub> emissions has been carried out.

Different choices of “building-HVAC systems” solutions could influence remarkably primary energy requirements in order to obtain specific indoor climate conditions. Moreover, energy and environmental costs increase proportionally with decreasing envelope energy performances: thermal insulated and “hermetic” environments develop lower energetic cost. On the other side, observing preservation conditions such as suggested by Italian Standard UNI 10829 (Tab.1) emerge that a number artefact categories do not request a level of control as high as defined by ASHRAE AA class (Tab.2), characterised by high energy demand.

The simulations aim is to highlight the relationship between indoor climate quality, energetic costs and CO<sub>2</sub> emissions. The study, developed through dynamic numerical model by using the simulation the software Energy-Plus [4], has investigated the combination of the variables characterizing the “building-HVAC system” shown in Table 4, describing the characteristics in terms of thermal insulation, thermal capacity and air permeability of the



building envelop and of the HVAC system (plant system). Climatic data (IGDG) of Turin are used for the simulation.

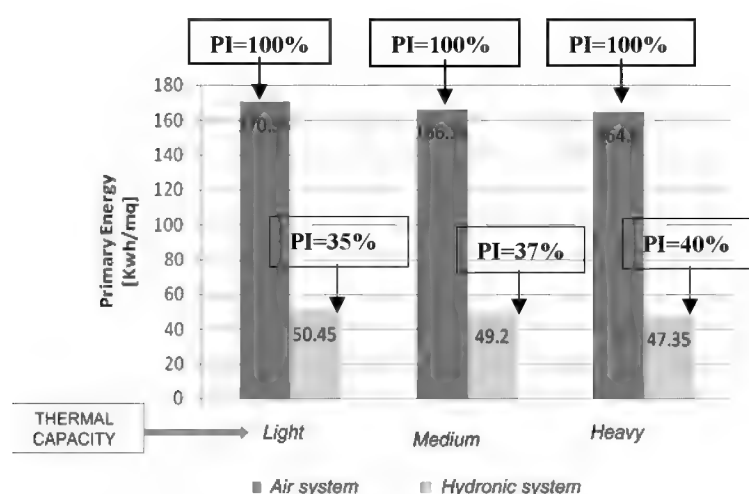
**Table 4.** Simulated building-HVAC systems

ENVELOPES				PLANT SYSTEM
Insulation	Not insulated	U = 1 W/m2K		No system (No mechanical control)
	Well insulated	U = 0.3 W/m2K		
Air permeability	Low permeability	N* infiltrations	0 l/h	Hydronic system (temperature mechanical control for heating and cooling)
	High permeability	N* infiltrations	0.25 l/h	
Thermal capacity	Light: 800kg/m³ if it is insulated (I) and not air permeable (NP) 220 kg/m³ if it is not insulated (NI) and air permeable (P)			Air system (temperature and relative humidity mechanical control for all conditions)
	Medium: 1500 kg/m³ if I - NP, 850 kg/m³ if NI - P)			
	Heavy: 2850 kg/m³ if I - NP, 1650 kg/m³ if NI - P)			

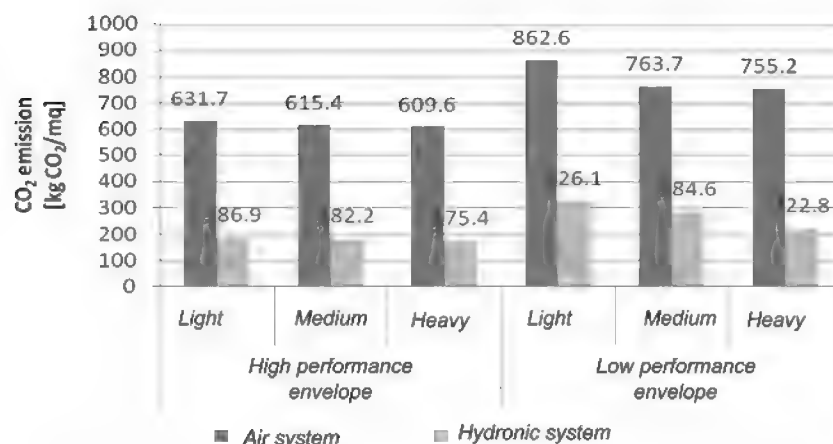
Firstly an hydronic system is investigated, controlling temperature only; in a second time an all-air system is analysed, controlling both temperature and relative humidity. Energy requirements for maintaining specific thermo-hygrometric values are evaluated for each analyzed case and, consequently, electricity and natural gas demand are determined in order to obtain primary energy through the appropriate conversion factors. The main results of the study are presented and examined below: the goal is to highlight how deep the energy demand and environmental impacts are related to the required microclimatic control, depending the building-HVAC system characteristics. Figure 3 and figure 4 show primary energy demands and CO<sub>2</sub> emissions for some simulated “building-HVAC systems”.

In particular, the graph in figure 3 shows the specific primary energy for indoor climate control, in case of an insulated envelope, according to the changes of the envelope thermal capacity and the installed system. Obviously, the obtained indoor climate quality is significant different: it can be synthetically evaluated through the Performance Index [5] expressing the percentage of time when climate parameters are in the acceptability intervals. With an all-air system the Performance Index reaches his maximum (PI= 100%) for every kind of envelop simulated; instead, with an hydronic system, lower PI values are obtained (PI around 37%). On the other side, the figure highlights that an all-air system consumption is remarkably higher than an hydronic system. Primary energy demand rise from 50 kWh/m<sup>2</sup> to 170 kWh/m<sup>2</sup> in the case of a light thermal mass envelop: energetic costs increase is about 240 %.

The CO<sub>2</sub> emission is an index related to the “environmental impact” (fig. 4). The environmental impact is determined by converting kWh/m<sup>2</sup> of primary energy into kg of CO<sub>2</sub>/m<sup>2</sup> through the primary energy conversion factor (= 0.27 kg CO<sub>2</sub>/kWh natural gas and =0.61 kg/kWh electricity [3]). Also in this case, the values related to the carbon dioxide emissions into the environment are higher for low performance envelopes (low insulation and high air permeability), and for the simulated environments with primary air system (but it's the case to remember that these latest ones rise the excellent indoor climate control). Moreover, figure 4 indicates the specific CO<sub>2</sub> emissions (referred to the usable floor space) for indoor climate control, both in case of an high performance envelope, and a low performance envelope, according to the changes of the envelope thermal capacity and the installed system. In this evaluation too, all-air system has an higher environmental impact than the hydronic system.



**Figure 3.** Primary energy demand: hydronic system and all-air system



**Figure 4.** Environmental impact: hydronic system and all-air system

The energy simulation results show that it is worth focusing on improving the thermal and air permeability performances of the building envelope, in order to both reduce energy consumptions and environmental impact, and improve the comfort conditions for the works of art and at the same time saving energy. To this aim, it is essential to reduce air infiltrations into the exhibition areas as much as possible, in order to prevent strong instability of the thermo-hygrometric conditions and to reduce energy demand due to ventilation. Moreover, the results highlight the significant increase of the energy requirements in order to go through one microclimatic control class to an higher one. Museum curators have to carefully consider this aspect, because they ought to ensure an adequate microclimatic control and, at the same time, are to be aware too close indoor climatic acceptability fields cause enormous environmental impacts. This theme has to be well realized in view of “green museum” focused on low CO<sub>2</sub> emissions.

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## AN INTELLIGENT EXPERT SYSTEM FOR IMPROVEMENT OF INDOOR AIR QUALITY IN MUSEUM ENVIRONMENTS

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Conservation of indoor air quality in healthy conditions has generally important effects on the invaluable objects kept in museums. Some researchers believe that managing indoor air quality is one of the most important issues for museums environment. So, emphasis would be on the evaluation of control equipments use within such environments. In this paper, an intelligent expert system for improvement of air quality in museums, AZTA, is presented. This system, designed by the authors, has abilities to compare indoor concentration of some pollutants, such as Nitrogen dioxide, Sulfur dioxide, Ozone, Particulate Matters and environmental parameter such as temperature and humidity with standard or guideline values and alarm the AZTA user if such limits are exceeded. In addition AZTA offers optimized air change rate per hour as well as most effective equipments with their technical characteristics considered fit for the environment. AZTA has been applied to two museums in Tehran-Iran, namely Pardisan Biodiversity and Persian Carpets museums of Iran. Results show that application of AZTA to offer control systems for indoor air quality, managed to propose alternative which focus on about 3 to 5 folds improvement in energy management at the same time attaining to acceptable indoor air quality.

## MODELLING OF INDOOR AIR QUALITY IN PARDISAN BIODIVERSITY AND PERSIAN CARPET MUSEUMS IN IRAN

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### Abstract

In many peoples' minds, air pollution is associated with the contamination of urban air from automobile exhausts and industrial emissions. Growing number of scientific evidence has indicated that in industrialized societies, air within buildings can be more seriously polluted than the outdoor air. In the last couple of decades, with the widespread availability of personal computers, mathematical modelling has also begun to be used to understand air pollution behaviour and effects on cultural heritages and personal collections kept in museums. The conservation of invaluable items such as cultural heritages exhibited inside museums is influenced considerably by the indoor environment, particularly indoor air quality with emphasis on gaseous and particulate matters. These air pollutants play an important role in the deterioration of these items. Therefore, this paper foresees an examining of the air quality in museums using mathematical modelling techniques for Indoor Air Quality, IAQ.

Two case-studies are carried out in Pardisan Biodiversity Museum and Persian Carpet Museum in Tehran-Iran. These museums are situated in the central part of the city and adjacent to crowded streets and highways. The major driving pollutants such as NO, NO<sub>2</sub> and SO<sub>2</sub> in and outside of the museums have been measured, analysed and the results have been used for modelling purposes. This research focuses on examining a masterwork IAQ model namely IMPACT to compare its ability in estimating concentration of pollutants and the amount of error with real measured concentrations. The results confirm that there is good agreement between predictions made by IMPACT model with real concentrations. This agreement is in the range of 77% to 94%. This paper ends with some recommendations for improving museum's IAQ management.

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**Keywords:** Air Pollution, Indoor, Modeling, IMPACT, Museum.

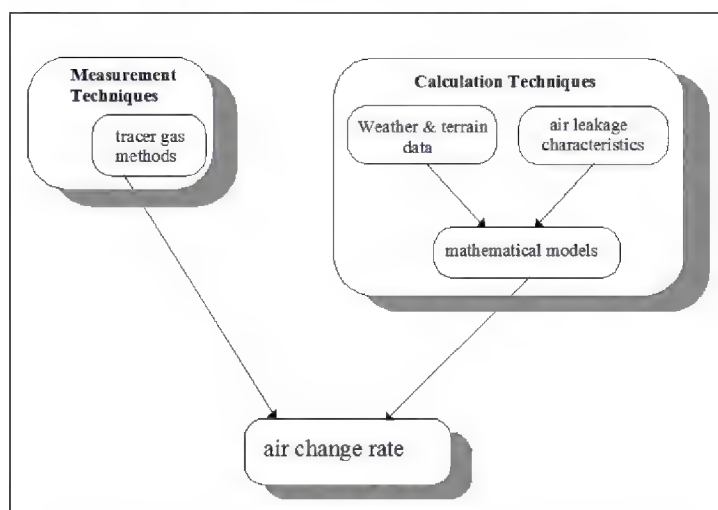
### Introduction

Indoor air quality (IAQ) generally refers to the quality of physical, chemical and biological characteristics of the air in the indoor environment within a building and could be dangerous for peoples' health. Indoor air pollution in buildings, is a result of the interactions between the site, climate, heating and air-conditioning systems, construction techniques, contaminant sources from building materials, furnishing, moisture, processes and activities within the building, building occupants' activity and outdoor sources. In many peoples' minds air pollution is associated with the contamination of urban air from automobile exhausts and industrial emissions. However, in developing countries, the problem of indoor air pollution far outweighs the ambient air pollution. There are four principal sources of indoor air pollutants: (1) combustion, (2) building material, (3) the ground under the building, and (4) bioaerosols [1]. Research indicates that most people spend approximately 80 percent of their lives indoors. Thus, for this group, the danger of health might be worse due to exposure to indoor air pollution in comparison with the outdoor. To provide good indoor air quality or to calculate a building's space-conditioning loads, it is important to know the air-flow pattern within the building. Accurate air flow information is also necessary for correctly sizing space conditioning equipment [2]. There are two fundamental approaches to determining the air-flow rate in buildings: measurement and mathematical modelling [3]. *Fig 1* shows the most straightforward method, e.g., measurement, by using a tracer gas technique. Multiple tracer gases can be used to track air flows between the inside and the outside of a building as well as between interior zones [4]. Air flow path indoors can be determined by the effects of infiltration, natural and mechanical ventilation on indoor air quality. Tracer gas measurements give a value for air flows only under prevailing leakage and weather conditions. Expending a lot of money for measuring and intolerance of this data in other places, are other problems of this method. On the other hand any change in temperature, humidity even passing time could offset the accuracy of measurements. In this method it is impossible to predict the concentration of pollutants in future, so this opportunity would be missed to evaluate or improve eventual condition.

Another method for predicting the concentration of indoor pollutants, in order to evaluate the air quality is using mathematical models. In the last couple of decades, with the widespread availability of personal computers, mathematical modelling has also begun to be used to understand indoor air pollution behaviour and their respective effects on valuable items in museums and or private collections [5]. Mathematical models can determine infiltration values for all leakage and weather combinations. Interzonal air flow models that are used for evaluating air quality have been divided into two main categories: Macroscopic and Microscopic models. Macroscopic models are divided into two groups itself, Single zone and Multizone models. Single zone models, assume that a building can be described by a single, well-mixed zone. These models are most often used for the single story, single family houses with no internal partitions (all internal doors are open) and similar. Unfortunately, single-zone models are also often used to calculate air flows in multizone structures, which goes beyond the limits such models [6]. For detailed



research use, it is recommended to use models in which more than one well mixed zone is conceivable. In multizone models, it is necessary to identify and describe all the zones of interest and links and flow paths between those zones and the outside air. The network of links is described by a series of flow equations which are solved simultaneously to provide air flow rates between rooms. A mass balance calculation in each zone at each time step can be included in a multizone model to predict the variation of concentrations with time.



**Fig1:** Alternative routes to the estimation of air change rates [3].

Indoor air pollution could threaten health of people indoor and on the other hand has long been recognised as a significant agent of deterioration of cultural heritage collections housed in museum, gallery, archive and library buildings. Gases that cause damage to the material heritages will, by definition, be those that have significant deposition onto indoor surfaces, be it objects or parts of the building fabric. The most important gases that are sourced outdoors have long been considered to be sulphur dioxide, nitrogen dioxide and ozone. Their main sources are, respectively fossil fuel combustion (sulphur dioxide and nitrogen dioxide), motor vehicle emissions (nitrogen dioxide) and photochemical reactions of those emissions (ozone) [7]. Considering invaluable objects in museums and cultural heritage buildings' and importance of maintaining them, it is necessary to use a method with the capability to estimate the concentration of indoor pollutants and evaluate their effects on collections. So in this research, attempts have been focused to survey concentration of pollutants in two important museums in Iran and consequently the data produced adopted by mathematical models, are compared with real measured data. In this way one can evaluate authenticity and accuracy of predictions of the model and use the results to outline different recommendations for improvement of indoor air quality (IAQ). IMPACT<sup>1</sup> model has been developed as a software tool for estimating the levels of damaging air pollutants concentrations inside cultural heritage buildings such as museums, galleries, archives, libraries and historic houses [8]. In this research two museums in Tehran, namely Pardisan Biodiversity Museum and Persian Carpet Museum have been used for investigation.

## 1. Museums Studied

### 2.1 Pardisan Museum

Pardisan Biodiversity Museum is in Pardisan Park with an area of 1,317 m<sup>2</sup>. The museum is confined between four crowded highways located in Tehran- Iran. These four highways around the museum cause a large amount of pollutants emitted from automobile exhausts, entering the museum causing damages to valuable exhibited items. Main entrance of the Pardisan Museum is placed on the north-western side of the building. In this museum some objects are in glassy showcases and some others are mounted on the walls. The floor of the museum building and some parts of the walls are covered with decorative stones and the rest of walls are painted. Taxidermy specimens are placed in painted backgrounds, named diorama, to illustrate the environment in which the natural habitats of the specimens are best known.

### 2.2 Persian Carpet Museum

Persian Carpet Museum of Iran is located on the north side of the Laleh Park passing two heavily congested streets along the eastern and western sides of the park. This museum has a very spectacular architectural design. Persian Carpet Museum has two halls with total area of 3,400 m<sup>2</sup> and has been used for exhibiting rugs, carpets and carpet pictures'. Two floors with a wide void opening in the middle of the halls. Inside are the most inestimable carpets from the 9<sup>th</sup> century to today. Since this museum is placed in a relatively polluted part of the city, then indoor air

quality is influenced by air pollution of the outdoors. Floors and walls are covered by heavy fabrics and paint. A small part of walls are covered by decorative stone.

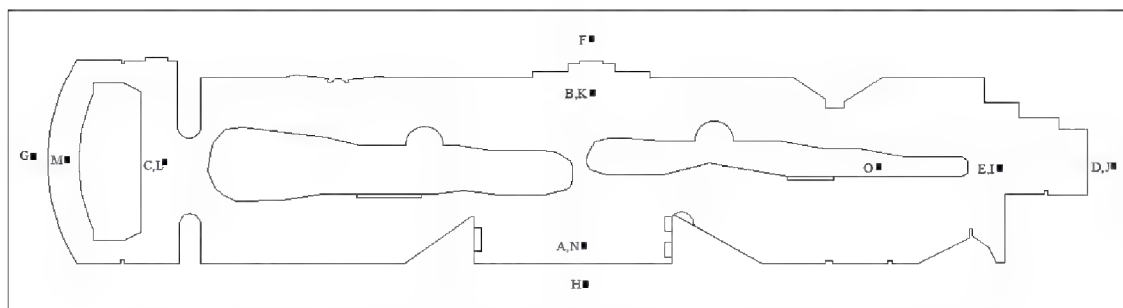
## 2. Adopted Approach

### 3.1 Measurement method

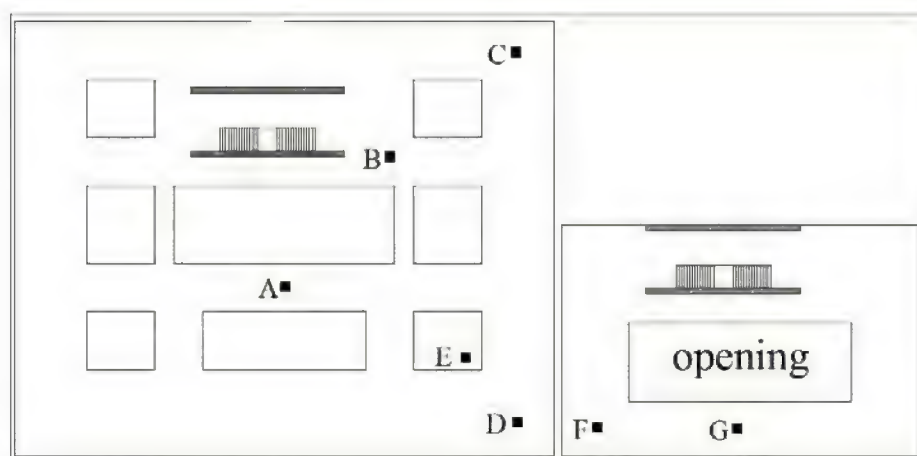
Concentration of two important pollutants namely  $\text{NO}_2$  and  $\text{SO}_2$  were to be determined in this research. These pollutants have long been recognised as a significant agent of deterioration for cultural heritage collections kept in museum, gallery, archive and library buildings.

Nitrogen dioxide ( $\text{NO}_2$ ) is dispersed in air by fossil fuels combustion contributed by motor vehicle emissions, whilst the main source for sulphur dioxide ( $\text{SO}_2$ ) is fossil fuel combustion, from stationary as well as mobile sources. Photochemical reactions of  $\text{NO}_2$  and unburned hydrocarbons (HC) emissions create ozone ( $\text{O}_3$ ). Some equipment such as heaters, electronic laser printers and photocopiers could also emit  $\text{NO}_2$ , HC and  $\text{O}_3$  indoors. But these appliances are normally specifically excluded from open spaces in museums. Sometimes building materials and tobacco smokes could participate in emissions. For pollutants measurement in Pardisan Museum, this point was acknowledged and thus measurements were made a long time after painting of dioramas to eliminate such effects. In *Figures 2 and 3* the plan of Pardisan Biodiversity Museum, Persian Carpet Museum and measurement locations' are shown. Sampling was performed in March 2008 and between 10-12 in the morning for Pardisan museum and 3-4:30 in the afternoon for Persian Carpet Museum. These times are the peaks for traffic volumes in the adjacent highways and streets. Sampling was performed by means of filling tedlar bags. Sampling point was at a height of 60 cm from the floor and far enough from the walls. Sampling indoor air quality was performed to compare the real concentration of pollutants obtained from measurements with the results produced later by mathematical models. Since museum buildings' studied have longitudinal shapes and is possible that concentrations of pollutants differ from one side to the other or may change during a short period of time, it was required to implement the measurements at four different sides of each building in the indoor and outdoor, repeated twice with a short time delay in between. Ventilation in Pardisan Museum is performed naturally. As shown in Figure 3, sampling in Persian Carpet Museum was performed in central parts, alongside the walls, near the main entrance and outside of the building.

*Tables 1 and 2* show the measured data. It is necessary to insinuate that averages of measured values have been used in the models to indirectly include periods and locations of sampling points.



**Fig 2:** Pardisan Biodiversity Museums site plan and measurement locations



**Fig 3:** Persian Carpet Museum site plan and measurement locations

**Table1:** Concentration of pollutants in Pardisan Museum

<i>NO</i>	<i>Location</i>	<i>Time</i>	<i>SO<sub>2</sub> (ppb)</i>	<i>NO<sub>2</sub> (ppb)</i>
1	A	10:00	6.24	22.96
2	B	10:10	6.71	27.31
3	C	10:20	6.51	27.41
4	D	10:35	5.93	23.96
5	E	10:41	6.79	24.15
6	F	10:50	7.14	23.73
7	G	11:00	6.97	23.33
8	H	11:08	6.56	24.34
9	I	11:15	6.36	27.05
10	J	11:25	6.31	24.38
11	K	11:30	6.24	27.25
12	L	11:40	6.37	26.96
13	M	11:50	6.18	23.97
14	N	12:00	5.68	22.40
15	O	12:30	6.44	26.72

<i>Average</i>	<i>SO<sub>2</sub> (ppb)</i>	<i>NO<sub>2</sub> (ppb)</i>
<i>Outdoors</i>	6.764	24.52
<i>Indoors</i>	6.25	25.201

**Table2:** Concentration of pollutants in Persian Carpet Museum

<i>NO</i>	<i>Location</i>	<i>Time</i>	<i>SO<sub>2</sub> (ppb)</i>	<i>NO<sub>2</sub> (ppb)</i>
1	A	15:20	6.38	24.40
2	B	15:30	6.24	23.82
3	C	15:45	5.98	31.13
4	D	15:50	5.65	28.60
5	E	16:05	5.94	30.94
6	F	16:15	6.43	27.51
7	G	16:20	5.59	28.29
8	H	16:37	5.89	23.49

<i>Average</i>	<i>SO<sub>2</sub> (ppb)</i>	<i>NO<sub>2</sub> (ppb)</i>
<i>Outdoors</i>	5.89	23.49
<i>Indoors</i>	6.03	27.81

### 3.2 Mathematical Modelling

After measurement of pollutants' concentration, a mathematical model was used to evaluate the indoors concentrations in order to be able to predict the circumstances in future. IMPACT model was selected for this purpose. IMPACT was a European Commission RTD<sup>2</sup> project. This project has developed a software tool to evaluate concentration of special pollutants inside museums, galleries, archives, libraries and historic houses. Special pollutants considered consist of sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>) and ozone (O<sub>3</sub>). IMPACT is a single zone model so it is necessary to pay attention to links and relations between zones. This model is JAVA applet<sup>3</sup> and is made of two software tools. First part uses deposition equation to predict concentration of pollutants

in naturally ventilation buildings. Second part is such as the first part but it uses a filter and mechanical ventilation model to evaluate concentrations indoor. This model relates the indoor/ outdoor pollutant ratio ( $C_i/C_o$ ) directly to building parameters and assumes the zone to be modelled, which could be a whole building, room or gallery or display case, as a single well-mixed zone. Wechsler equation has been used in this model [8]:

$$\frac{C_i}{C_o} = \frac{\lambda}{\lambda + \frac{V_d A}{V}} \quad (1)$$

In this equation,  $C_i$  is indoor concentration,  $C_o$  is outdoor concentration,  $\lambda$  is air change rate,  $A/V$  is surface area of interior ( $\text{m}^2$ )/volume ( $\text{m}^3$ ), and  $V_d$  is deposition velocity ( $\text{cm s}^{-1}$ ), a measure of how well a particular surface takes up a pollutant [9,10].

Wechsler equation has assumptions such as: the principal mechanism for reactive pollutant removal in the indoor environment (assuming no filtration) is heterogeneous reaction and homogeneous reactions (gas-gas interactions) are considered to be insignificant. Thus in this model focus is on the reaction between pollutants gas and indoor surfaces and will not contemplate changes. This could be a problem in this model. However homogeneous reactions can also be discounted for  $\text{SO}_2$  but they are known to play a part in the formation and decomposition of  $\text{NO}_2$  and  $\text{O}_3$  [11].

Another underlying assumption is that the only source of gaseous pollutants is the outdoors and that there are no indoor sources. As illustrated before, these mechanisms that produce pollutants, are normally specifically excluded from collections spaces, so the assumption of no indoor sources is valid for these spaces. Objects and materials do not have the ability to metabolise pollution, but instead, slowly react with them over time, then accumulating damage with the overall pollutant dose and concentration over time that they receive.

A very salient and innovative feature of this model is accounting for materials and coverings that are used indoor. This parameter can be used for evaluating how well a particular pollutant gas will react and deposit on a particular surface material.

In this model some probabilities are assumed such as reaction and decomposition may re-emit after a short time. Deposition velocity in this model is assumed with an equilibrium condition between deposition and re-emission from surfaces. Thus for a gas which is not very reactive at surfaces, it is possible to have a low deposition velocity. Since when the pollutants come into contact with a surface, there is a lower probability of reaction and decomposition, and it may simply be re-emitted after a short time. Reaction and re-emission procedures' are influenced by temperature and humidity. So in some cases, growth in humidity could increase reaction probability between gaseous pollutants, particularly for acidic reactions involving  $\text{SO}_2$  and  $\text{NO}_2$ , and less so for oxidative reactions, such as those involving  $\text{O}_3$ .

With this explanation, IMPACT inputs consist of pollutant concentrations, indoor and outdoor temperature, relative humidity, wind speed, interior volume and surface covering materials used indoor. The model outputs are:

- 1- Indoor/outdoor ratio for pollutant (I/O), thus concentration of pollutants indoor may be calculated by the outdoor concentration.
- 2- A pie chart showing amount of deposition for different surfaces. Pie chart is an important and effective indicator for reduction or elimination of the pollutants.
- 3- The deposition velocity values for the selected surface materials will be represented as an output.
- 4- Graphs of I/O ratio versus air change rate which show how building pollution levels vary with differing air change rates [8].

In another step, it was necessary to calculate interior volume as well as different materials used for covering the surfaces in museums with their respective areas. In IMPACT model, it is enough to recount some principal and main materials and stuffs in buildings as inputs. Therefore environmental parameters such as temperature, humidity and wind speed would be required to be determined. *Tables 3 and 4* show determined parameters and IMPACT inputs'.



**Table3:** IMPACT model inputs in Pardisan Museum

Environmental parameter		Internal surfaces	Area (m <sup>2</sup> )
Volume	4478 m <sup>3</sup>	Painting	1150
Outdoor temp.	14 °C	Glass	532.3
Indoor temp.	19 °C	Marble	1313
RH	40%	Ceiling	888
Air change/Hour	3	Metal	186
Wind speed	9 m/s	No material	62.7
(Mehrabad 10 m)		Granite	15

**Table 4:** IMPACT model inputs in Persian Carpet Museum

Environmental parameter		Internal surfaces	Area(m <sup>2</sup> )
Volume	10408 m <sup>3</sup>	Cloth	3577
Outdoor temp.	13 °C	Glass	151
Indoor temp.	20 °C	Painting	657.5
RH	40%	Stone	313.6
Air change/Hour	2	Metal	3146
Wind speed	2 m/s		
(Mehrabad 10 m)			

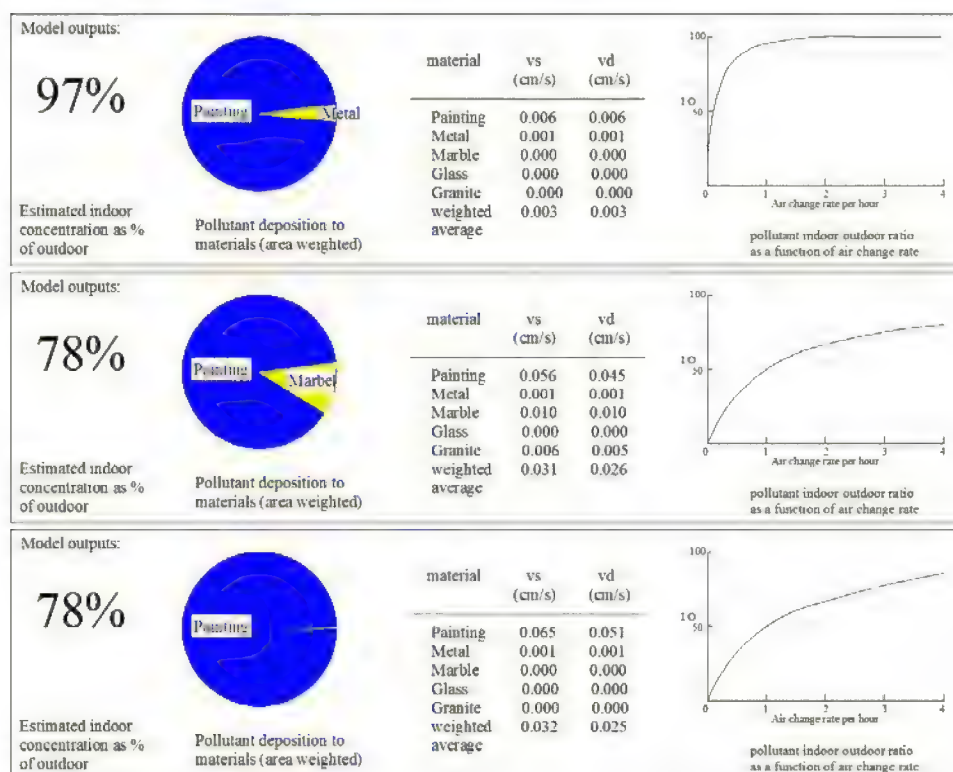
### 3. Discussion of Results

After measurements of pollutants concentrations outdoors and determining surface areas of covering materials, the model was used to predict concentration of indoor pollutants. The building air change rates, can be measured using specialized and expensive methods, therefore an inexpensive method is provided for model users to determine air change rates by means of using outdoor temperature (°C) and wind speed (ms<sup>-1</sup>).

#### 4.1 Modeling results for Pardisan Biodiversity Museum

IMPACT model outputs for different pollutants of NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub> is shown in *Figure 4*. In the left a value is introduced as a percentage. This parameter indicates the indoor to outdoor ratio for selected pollutant. Indoor concentration may be estimated by multiplying this value in the outdoor concentrations. Pie charts in the figures show adsorption capacity for different materials. For example main parts of pollutants are adsorbed by painting and a little of that is adsorbed by stone and metal. Some materials such as glass do not play an effective part in adsorption of pollutants. Other outputs in this model are a table for illustrating deposition velocities for materials and a graph to show building pollution levels variation with differing air change rates.

Effective role of some materials in absorption and reduction in air pollution values can be understood. This note can be used to improve indoor air quality, for example by increasing the in effective surfaces in pollutant adsorption and better choice in designing before construction. Another important point is a graph that shows variation in pollution levels in relation to differing air change rate. Sharp slope in this graph indicates severe relationship between indoor air quality and air change rate. Hence one of the effective methods for reducing the pollutant levels indoor, especially nitrogen dioxide, is to reduce air change rate by means of air tightening and gasketing. Relation between pollutants levels and air change rate is more serious for NO<sub>2</sub> than the other pollutants.



**Fig 4:** IMPACT model results for NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub>, respectively in Pardisan Museum

**Table5:** Comparison between IMPACT results with measured data in Pardisan Museum

Results	SO <sub>2</sub> (ppb)	NO <sub>2</sub> (ppb)
Modeled	5.28	23.78
Measured	6.25	25.201
Accuracy level	84 %	94 %

In order to improve indoor air quality and reduce pollutant concentrations, different techniques should be surveyed. For example reducing air change rate from 3 to 1.5 viz-a-viz air tightness in Pardisan Museum, and keeping other parameters constant, air pollutant concentration will decrease. Another option offered would be using a ventilation system that is equipped with a filter, with different efficiencies for example 60% and 80%, and recirculates 80% of air indoor, and air intake is air change rate per hour.

For *table 6*, one may compare present conditions with offered improving air quality options in order to evaluate the obtained results.

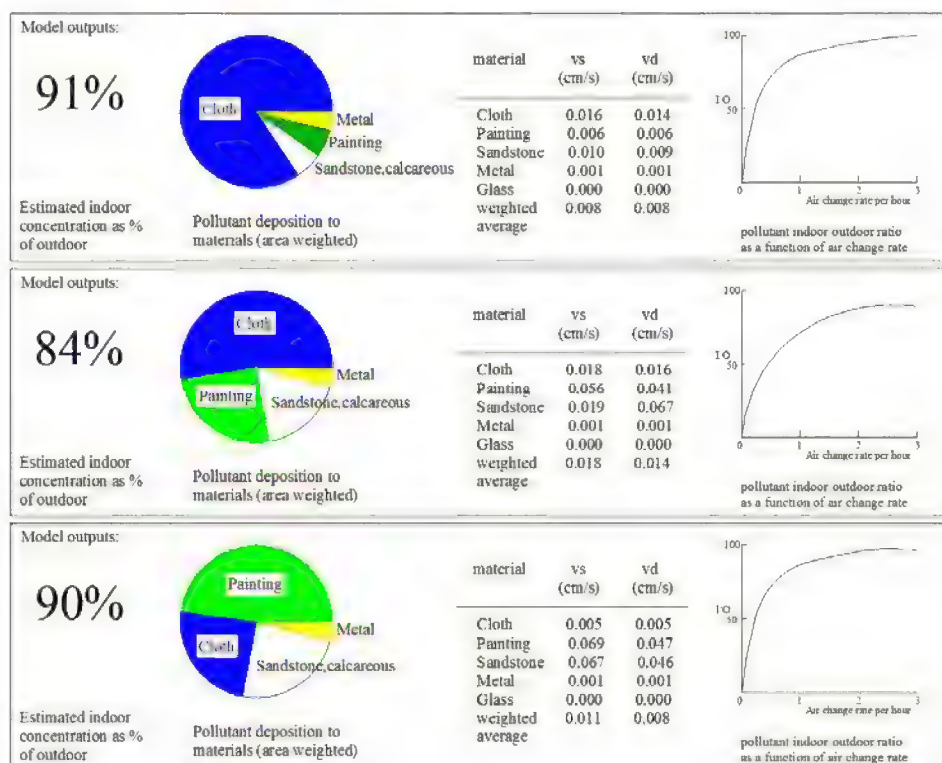
**Table6:** Comparison between IMPACT results with offered methods in Pardisan Museum

Results	NO <sub>2</sub> (ppb)	SO <sub>2</sub> (ppb)	O <sub>3</sub> (%)
Modeled	23.78	5.28	78
Decrease ach to 1.5	23.05	4.60	69
Using ventilation & filter (60%)	16.43	3.92	58
Using ventilation & filter (80%)	14.71	3.52	52
Integrating both methods (ach + filter 60 %)	16.18	3.45	51
Integrating both methods (ach + filter 80 %)	14.47	3.11	46

*Table 6* shows that some changes in the building, for example reduction in air change rates, using mechanical ventilation and filter, or increase of adsorbent surfaces and other methods, could be effective in controlling the indoor air pollution. This method is studied in the Persian Carpet Museum as follows.

#### 4.1 Modeling results for Persian Museum

For Persian Carpet Museum, methods used for Pardisan Museum as described in 4.1 were repeated. An important point about this museum is that indoor air was more polluted than the outdoor air. IMPACT results for this museum are shown in Figure 5.



**Fig 5:** IMPACT model results for NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub> in Persian Carpet Museum

The comparison of Persian Carpet Museum results with those achieved in Pardisan Museum reveals that more materials participated in the adsorption of pollutants in Persian Carpet Museum. Pie charts show important role of cloth, painting and sandstone, calcareous in reduction of air pollutants concentration. Cloth in Persian Carpet Museum consists of rugs, carpets and heavy fabrics used in the inner decoration of the building. So it is predictable that valuable objects maintained in this museum such as rugs, are at serious risk and it is necessary to prevent direct exposures with air and attempts should be made to improve indoor air quality.

**Table7:** Comparison between IMPACT results with measured data in Persian Carpet Museum

Results	SO <sub>2</sub> (ppb)	NO <sub>2</sub> (ppb)
Modeled	4.95	21.38
Measured	6.03	27.81
Accuracy level	82 %	77 %

Some suggestions may improve indoor air quality and reduce air pollutant levels in Persian Carpet Museum. For example decreasing air change rate from 2 to 1, by making some changes in entrance of the museum, using a ventilation system, similar in characteristics to Pardisan Museum, or integrating both methods, reduction in air pollutants concentration is achievable. In table 8 effects of these suggestions are shown.

**Table8:** Comparison between IMPACT results with offered methods in Persian Carpet Museum

Results	NO <sub>2</sub> (ppb)	SO <sub>2</sub> (ppb)	O <sub>3</sub> (%)
Modeled	21.38	4.95	90
Decrease ach to 1.0	19.70	4.50	84
Using ventilation & filter (60%)	17.85	4.18	75
Using ventilation & filter (80%)	16.91	4.01	71
Integrating of both methods (ach + filter 60 %)	16.68	3.83	71
Integrating of both methods (ach + filter 80 %)	15.97	3.65	67

Analyzing these results, it is obvious that suggestions such as reduction of air change rates, using mechanical systems equipped with filter and synthetic methods have effective role on the improvement of indoor air quality. Synthesizing methods, could improve air quality conditions by 50%, which could constitute the best guideline, when compared with other suggestions.

#### 4. Conclusions

The most important result of this paper is compatibility between modeled results with real measured data. This value is in the range of 84%- 94% for Pardisan Biodiversity Museum and 77% - 82% for Persian Carpet Museum. Since Concentrations of the indoor pollutants in Persian Carpet Museum are more than the outdoor air, because the maximum level of pollutants that is predictable by IMPACT model is equal to the outdoor concentration, a reduction in accuracy of model is expected. Hence, the hypothesis of no indoor sources is valid with this explanation. For Pardisan Biodiversity Museum the level of indoor pollutants are similar to the outdoor levels and these effects would be related to superabundant rate of air change. The effects of different suggestions for improving indoor air quality are demonstrated. These suggestions are using mechanical systems, an effective filter, and reduction in air change rate or integrating the two. A useful capability of this model is the determining role of different covering surfaces in adsorption of pollutants. This point can be considered as an inexpensive way for air quality improvements. Selection of suitable covering surfaces in the building before construction can influence the adsorption of gaseous pollutants and improve indoor circumstances indirectly. Using this methodological approach, that is adopting such modeling activities as a regular procedure may be appropriate for improvement of standard of living and better indoor air quality in order to protect our invaluable items in museums even before using ventilation systems causing waste of energy and irreparable damage to our natural or human heritages.

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<sup>1</sup>Innovative Modelling of Museum Pollutants & Conservation Thresholds

<sup>2</sup>Recovery, Treatment & Disposal

<sup>3</sup>small application program that performs a specific task



## EVALUATION OF A MICROCLIMATE MONITORING SYSTEM APPLIED TO SMALL SIZE MUSEUMS.

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### Abstract

The conservation of works of art exhibited inside museums is influenced considerably by the indoor microclimatic conditions. Temperature and air moisture content variations and lighting play an important role in the deterioration of works of art, both artefact of historical-artistic value and demoethnoanthropological goods.

Small museums around the country are a source of pride for local people. They preserve and guarantee the transmission to future generations of important works of art or goods of cultural interest. In these contexts is not sustainable an environmental monitoring like that carried out in major museums, both for the high cost of equipment and management and for the lower influx of visitors.

The aim of this work has been to verify the conservation conditions of a remarkable collection of votive wood paintings housed in the Museum of the Basilica of the *Madonna della Quercia* (Viterbo, Italy), using simple instruments and tools.

Microclimatic environment characterization has been conducted from December 2008 to September 2009, surveying temperature and relative humidity.

Lux and radiation measures have been performed. Moreover punctual microclimatic surveys of surface temperature of a wooden votive tablet, as well as measurements of environment temperature, relative humidity and dew point have been carried out.

The results have been interpreted with reference to museum standards regarding the conservation of works of art, in order to verify compliance of the measured values with the optimal values of the parameters established by the legislation proposed by the Italian Ministry of Culture n. 238, 19-10-2001.

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**Keywords:** microclimate; conservation; wooden artefact, small museum

## 1. INTRODUCTION

### 1.1 Aim of the research

The conservation of works of art exhibited inside museums is influenced considerably by the indoor micro climatic conditions. Temperature and air moisture content variations and lighting play an important role in the deterioration of works of art, both artefact of historical-artistic value and demo ethno anthropological goods [1].

In fact, daily temperature and moisture cycles cause mechanical stress in wooden artefacts [2]. Under specific conditions, they also make wood susceptible to biotic degradation.

The behaviour is influenced even by the constituent materials, such as species and defects of the used wood, or by the execution techniques of the panels.

Small museums around the country are a source of pride for local people They preserve and guarantee the transmission to future generations of important works of art or goods of cultural interest. In these contexts an environmental monitoring like that carried out in major museums is not sustainable, both for the high cost of equipment and management and for the lower influx of visitors.

So the aim of the of this work has been to verify the conditions of conservation of a remarkable collection of votive wood paintings housed in the Museum of the Basilica of the *Madonna della Quercia* (Viterbo, Italy), using simple instruments and tools.

### 1.2 The votive tablets in the Museum of *Madonna della Quercia* Basilica (Viterbo, Italy)

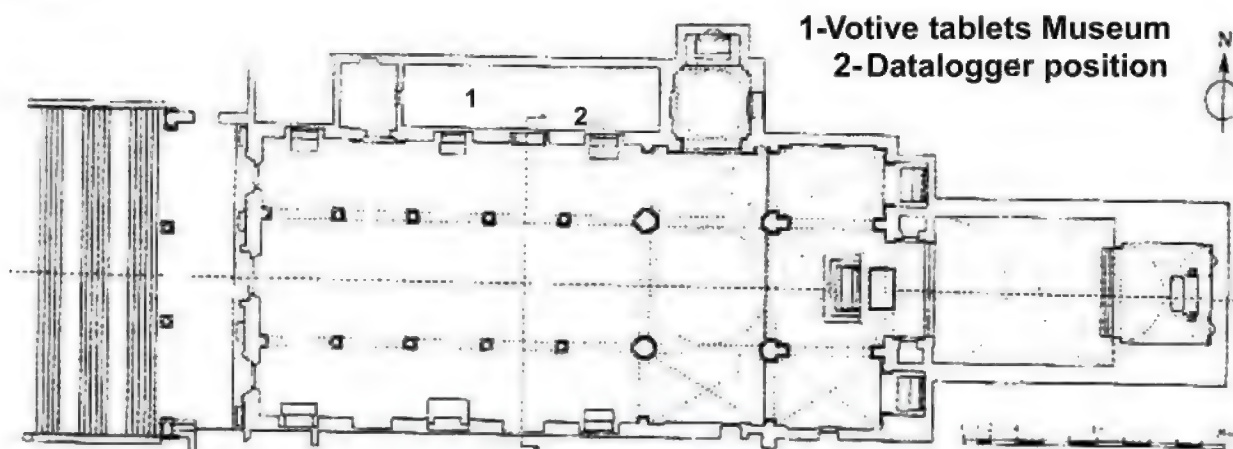
The cult of *Madonna della Quercia* image was born in 1467 and it spread in Viterbo territory and then in Central Italy [3]. The Museum of *Madonna della Quercia* Basilica (Viterbo, Italy) houses 204 *ex-voto* tablets. Most tablets date back to the 16<sup>th</sup> and 17<sup>th</sup> centuries. 15 of them have been attributed to the 15<sup>th</sup> century, 21 to the 18<sup>th</sup> century and 4 to the first half of the 19<sup>th</sup> century. The votive tablets are little wooden panels often painstaking as regards the iconographic details. But their original characteristic is devotional [4]. The votive tablets may also be considered a demo ethno anthropological document because the representations show some elements of a material culture, of language aspects and of symbology used for the writings.

The execution techniques of the *ex-voto* are often oil or tempera paintings. During the 16<sup>th</sup> and 17<sup>th</sup> centuries to these techniques the painting on paper, then applied to the wood panel, was added. Moreover some tablets were realized on canvas glued to the wood panel. Only one watercolor *ex-voto* was found. Six votive tablets of the 17<sup>th</sup> century have a printed paper base. Then the paper was modified in order to satisfy the requirements of the less well-off customers and glued to the wood panel.

### 1.3 Current environmental showroom

The Museum of votive tablets of Madonna della Quercia was set up in 1978 in the small room used as a "cloister of women" adjacent to the ancient architectural complex (Fig. 1).

Today the votive tablets are exposed on a panel covered by a canvas that avoids the contact of the wood supports with the wall (Fig. 2). On the opposite wall three windows are present. A window-door allows the access from the church.



**Fig. 1.** Map of the Museum (1) showing the location of the measuring instruments (2).



**Fig. 2.** The simple exhibition of the votive tablets in the museum. The panel avoids direct contact of wood supports with the walls.

## 2. EXPERIMENTAL SECTION

Micro climatic environment characterization was conducted from December 2008 to September 2009, surveying temperature and relative humidity. Data were recorded every 30 min, with a 175-H1 TESTO datalogger. Illuminance measures have been performed by means of a DeltaOhm Luxmeter HD 8366 equipped with a Si sensor. Radiance measurements have been realized through a portable HD2102.1 DeltaOhm radiometer equipped with total radiance, UVA and UVB probes.

Moreover punctual micro climatic surveys of surface temperature of a wooden votive tablet, as well as measurements of environment temperature, relative humidity and dew point were carried out (from April to July 2009), using a 177-H1 TESTO datalogger.

The parameters used for the characterization of the supports have been examined on 15 votive tablets. In particular wood species, geometrical characteristics, wood defects and state of conservation of the support have been considered.

The characterization of the wooden species has been obtained by means of macroscopic examination and of observation of the thin sections of the wooden samples under optical microscope according to UNI 11118, 2004 [5]. Entomological monitoring has been carried out to control the effectiveness of treatments realized during the restoration completed in 1978.

### 3. RESULTS AND DISCUSSION

#### 3.1 Indoor environment

Maximum, minimum and average daily values of temperature and relative humidity were analyzed. The day and night averages values were taken into consideration in order to highlight any serious temperature variation that could occur suddenly. Weekly trend of temperature and relative humidity was studied in order to understand if the attendance of the faithful to church could affect microclimate.

In the museum there is no heating, but the room is adjacent to the left aisle of the church in which the religious services commonly are held and where there is an air heating system running every morning from 7 to 9.

Diurnal temperature and relative humidity average values exhibit only little differences in comparison with those of the night because of the enclosed environment and of the lack of artificial heating. For this reason the average values in the space of the entire day will be considered.

The fluctuations of daily temperatures (Fig. 3) were consistently low, showing a fairly stable situation. Temperature was particularly stable during the days dedicated to the liturgical celebrations from 23 to 25 December.

Daily variation of RH% (Fig. 4) in the months from December to February was around 1%, only occasionally RH variations reached values of 2.67 and 2.51%. These high variations of RH occurred on 26 December (RH% = 69.9 to 60.9) and 3 January (RH% = 68.7 to 60.6) and they are related probably to the influx of the faithful in the earlier liturgical days.

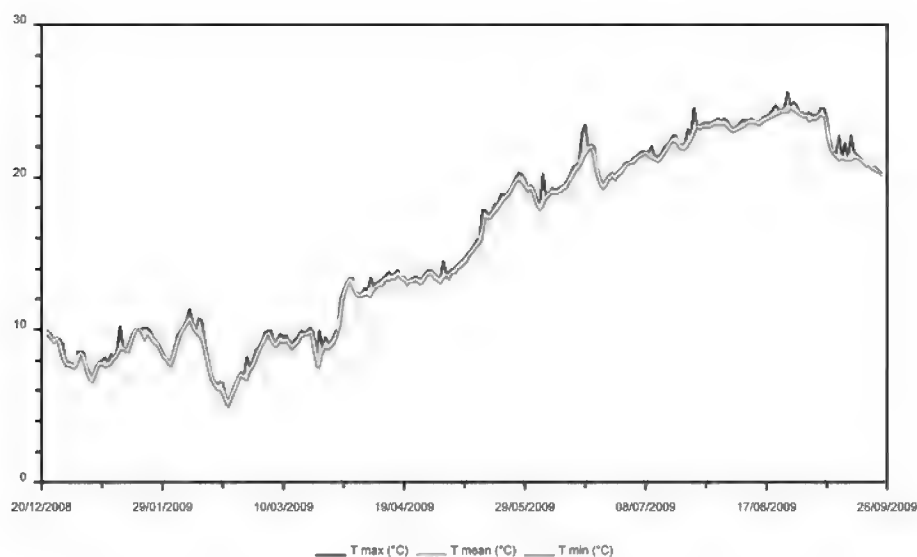
From March to September, the relative humidity was often higher than 70%. Even daily variations are high, with rates varying up to 6.4% (September).

The weekly trends of temperature and relative humidity show discordant behaviour during the period (data not reported).

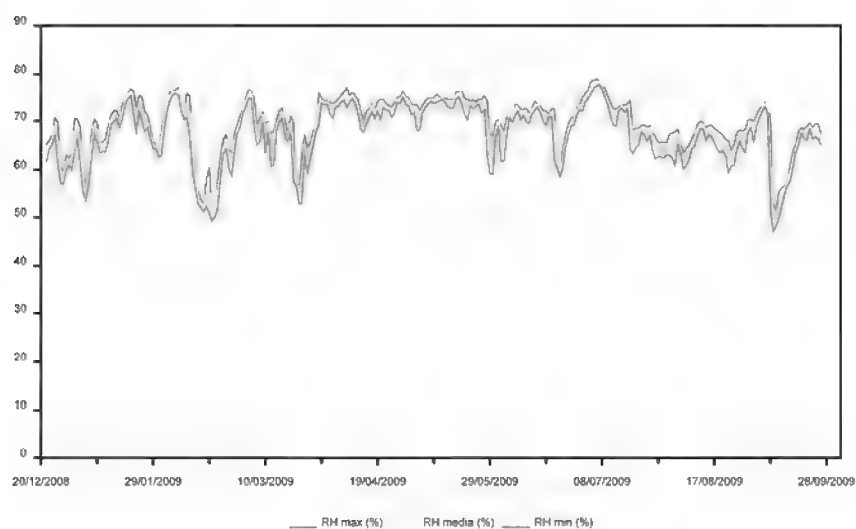
Temperature and humidity values were compared with the intervals of safety recommended for these types of artefacts. Thus, the relative humidity values were grouped into classes. The number of times, that these environmental safety values are exceeded, may give indications on possible measures to be taken to improve the environmental dynamics. These frequencies are reported in figure 5.

During January and March there were often high RH values, from 60% up to 70%. Probably this situation arises from the combination of low temperatures and poor air recirculation in the room. In April and May the RH values vary often between 70-75%, with temperature around 20°C: these microclimatic conditions are favourable to natural processes of biodeterioration. During August, the relative humidity never went beyond the critical value of 65%, while during July and September it has often reached high levels, until 70-75%.

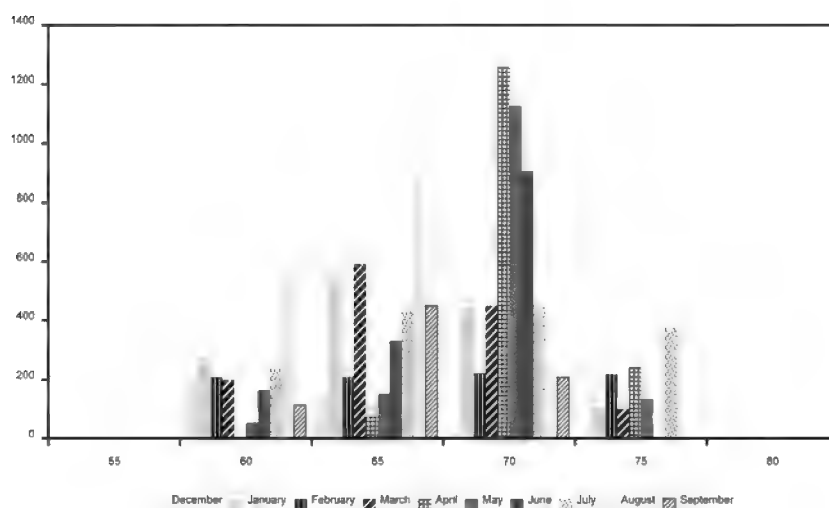
The tablets in the museum are subject to high relative humidity but low temperatures values. These last ones prevent the degradation activity on artefacts, but at the same time they make the environment uncomfortable for operators and visitors.



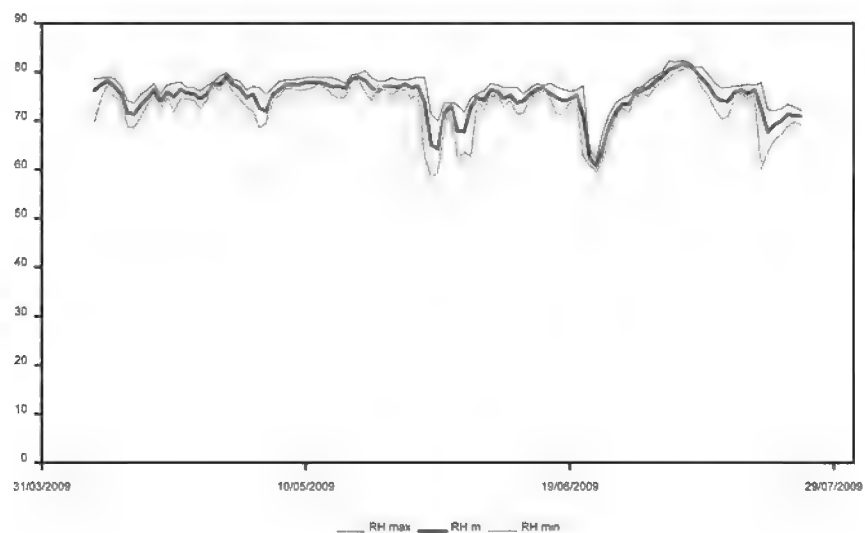
**Fig. 3.** Daily temperature (T °C) from December 2008 to September 2009.



**Fig. 4.** Daily relative humidity (RH %) from December 2008 to September 2009.



**Fig. 5.** Number of times that relative humidity (RH) values measured in museum exceeded the environmental safety values.



**Fig. 6.** Daily minimum (RH min), mean (RH mean), and maximum (RH max) relative humidity values (%) from April to July on the wood surface.



### 3.2 Measurements of the surface temperature of the wood, the dew point and relative humidity on the panel

The measurements were conducted from April to July.

The values on the surface of wood have been substantially homogeneous as regards the trend of environmental parameters.

The RH values show that on the surface of the artefacts limited daily fluctuations are determined (Fig. 6). However, the obtained values are far from the environmental parameters suggested by museum standards.

The dew point indicates the temperature at which moist air must be cooled to reach saturation. If a surface is cooled until it reaches the dew point temperature, the steam in the air begins to condense, forming a film of liquid water. Calculating the difference between air temperature and dew point, or distance from the dew point, may be useful to assess the risk. When the two parameters assume the same value condensation will be very likely.

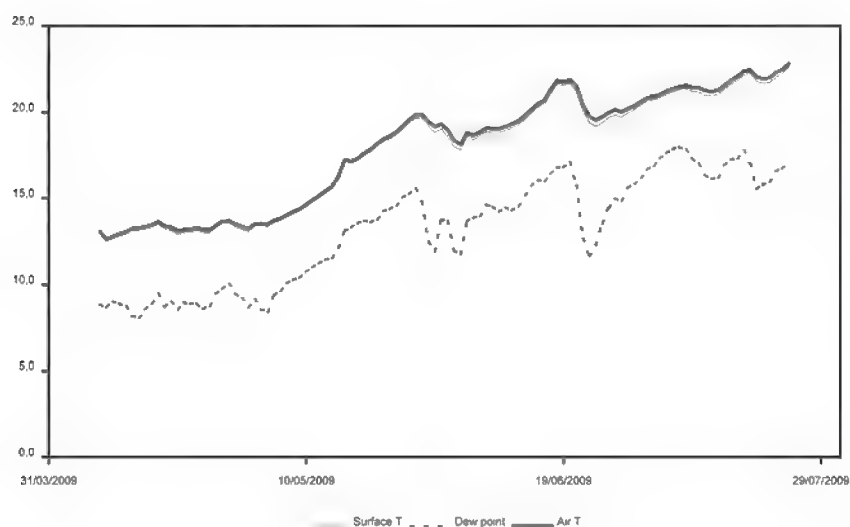
The data show that during the spring and summer it is unlikely the formation of condensation on surfaces. In fact the curves of air temperature and dew point temperature are far apart (Fig. 7).

### 3.3 Lighting

The lighting of the museum consists of 11 300 Watt halogen lamps. Illumination parameters were measured along the wall that houses the votive tablets. Measurements were taken at approximately 1.70 m above the ground, every meter. The results are summarized in table I.

The lighting is not suitable because there is an excess of illuminance, compared to values recommended by the museum standards. The replacement of the lighting is desirable.

Limited use of artificial lighting for low influx to the museum is paradoxically a positive force for conservation.



**Fig. 7.** Daily temperature on the wood surface, dew point, air temperature near wood (°C), from April to July.

### 3.4 Entomological monitoring

Entomological monitoring did not detect the presence of ongoing attacks. The action performed on the tablets during the restoration has been effective. Furthermore, the microclimate is probably little suitable to the development of insects.

Tab. I. Illuminance and irradiance parameters.

Illuminance (Lux)	Radiance – RAD (W/ m <sup>2</sup> )	UVA (W/ m <sup>2</sup> )
297	4,75	5,2·10 <sup>-3</sup>
315	5,06	4,7·10 <sup>-3</sup>
435	6,22	5,7·10 <sup>-3</sup>
250	3,83	1,8·10 <sup>-3</sup>
368	4,76	4,5·10 <sup>-3</sup>
326	4,61	3,4·10 <sup>-3</sup>
254	3,7	1,2·10 <sup>-3</sup>
420	5,85	4,3·10 <sup>-3</sup>
280	4,34	2,2·10 <sup>-3</sup>
328	5,15	3,2·10 <sup>-3</sup>
282	4,73	3·10 <sup>-3</sup>
188	3,09	1,4·10 <sup>-3</sup>
382	5,39	6,0·10 <sup>-3</sup>
322	4,7	6,0·10 <sup>-3</sup>
225	3,58	4,2·10 <sup>-3</sup>

### 3.5 Tablets characteristics

Support is made generally from a single board. Subradial cuts are favoured, in fact the wood panels are pith less. In this way the wood panel undergoes less dimensional variations [6], [7]. The wood panels show in fact limited cupping and the warping is generally scarcely perceptible (Tab. 2). Probably the wood stability of these tablets was considered important. In fact the wood panels are characterized by a considerable thickness compared to their length and breadth. It is well known that the support deformations caused by the environment thermo hygrometric variations are smaller if the wood panel thickness increases.

The most represented botanical species of the examined panels is *Castanea sativa* Mill.; *Populus* sp.(3 tablets) *Fagus sylvatica* L. (1 table) and *Pinus* sp.(1 table) have been also found.

The sapwood has been almost completely removed in the chestnut table. This shrewdness, that preserves the artefact from the insect attacks, is probably connected to the characteristic of the chestnut wood. This species, particularly in Central Italy, has a limited sapwood extension [8]. Sometimes little deeply worn off areas are visible. The fragility of these areas is due to the presence of larval burrows and it is characterized by xylematic tissue detachments.

The choice of the wood has been less careful as regards some defects like knots. This wood defect represents a trace of the branches inside the trunk. It is one of the main assortment defect being a localized heterogeneity factor. In fact the knot tissues, that exhibit a different orientation compared with the panel, have some reaction wood, a different hardness and density. The pith is sometimes present. It may undergo cracking in relation to anisotropy of shrinkage [9]. Several knots are present on the votive tablets, sometimes large-sized. They may cause cracking of the support that affects also the painting layers. In addition to cracking provoked by thermohygrometric variations of the environment, ring shake has been observed. It causes the detachment of adjacent rings, inducing cracks that affect the entire thickness of the board.

In most cases the votive tablet frames are today absent, but symmetric traces of nails indicate their past presence. Dark color is visible in correspondence of nail stems remained inside the support. Sometimes nails has started a cracking process.

In general it is possible to assess that the state of preservation of the tablets is quite stable.

**Tab. II.** *Characteristics of votive tablets wooden support.*

Tablet n.	Century (date on the tablet)	Side (cm)				Thickness (mm)	Cup		Cut	Grain direction
		R	L	I	S		L (mm)	R (mm)		
1	sec. XV	23,6	26,7	22,3	26,6	16,00 (I R) 15,40 (I L) 16,95 (S R) 16,39 (S L)	2,18	2,98	radial	vertical
14	sec. XV	27,0	27,0	36,0	35,5	10,48 (I R) 10,67 (I L) 9,71 (S R) 11,10 (S L)	0,00	0,00	subradial	horizontal
16	sec. XVI (1501)	21,7	20,5	22,4	36,4	19,36 (S R) 21,20 (S L) 21,08 (I L) 17,74 (I R)	20,89	2,01	sub tangenzial	horizontal
17	sec. XVI	20,7	20,7	28,8	28,8	18,30 (I R) 17,79 (I L) 19,09 (S R) 18,61 (S L)	6,90	6,05	subradial	horizontal
61	sec. XVI	21,0	21,5	32,0	33,4	17,40 (I L) 18,54 (I R) 17,69 (S L) 18,27 (S R)	4,68	0,00	subradial	horizontal
76	sec. XVI	30,9	30,5	14,3	17,3	17,63 (I R) 10,48 (I L) 17,60 (S R) 10,60 (S L)	0,00	0,00	subradial	horizontal
80	sec. XVI	22,0	22,8	26,7	25,0	22,15 (S Sx) 23,48 (S R) 24,74 (I R) 23,65 (I Sx)	3,52	3,30	subradial	horizontal
91	sec. XVII	12,0	13,0	20,5	22,1	6,89 (I R) 7,06 (I L) 6,82 (S R) 5,64 (S L)	0,00	0,00	subradial	vertical
96	sec. XVII	18,9	19,2	27,6	28,6	12,27 (S R) 10,50 (S L) 11,63 (I R) 12,45 (I L)	2,41	3,20	subradiale	horizontal
97	sec. XVII	25,3	25,3	30,0	29,7	20,00 (I R) 20,00 (I L) 23,34 (S R) 21,85 (S L)	2,18	3,08	subradial	horizontal
140	sec. XVII	20,0	20,0	26,7	27,2	14,02 (I R) 16,87 (I L) 14,91 (S R) 11,09 (S L)	1,50	0,92	subradial	horizontal
141	sec. XVII	18,3	17,5	25,3	25,1	23,18 (I R) 26,81 (I L) 24,66 (S R) 24,72 (S L)	0,00	0,00	subradial	horizontal
169	sec. XVII (1674)	26	24,5	19,3	21,0	33,75 (I R) 31,83 (I L) 32,96 (S R) 31,54 (S L)	3,13	3,67	subradial	horizontal
181	sec. XVII (1697)	19,0	20,0	18,8	18,4	23,48 (I R) 23,62 (I L) 23,43 (S R) 24,14 (S L)	2,63	1,97	subradial	vertical

#### 4. CONCLUSIONS

An interdisciplinary approach based on diagnostic tests has been used. This approach makes possible conservation actions based on a scientific methodology.

The results have been interpreted with reference to museum standards regarding the conservation of works of art. The aim has been to verify compliance of the measured values with the optimal values of the parameters established by the legislation proposed by the Italian Ministry of Culture n. 238, 19-10-2001.

The used instrumentation has helped to detect the basic data for the description of microclimate and to identify the best conservative context.

In particular, the study highlights some important aspects of the interdisciplinary approach to the wooden artefacts. The data of temperature and relative humidity collected during the survey of the microclimate allow to extrapolate the theoretical value of wood equilibrium moisture content. The values have converged to equilibrium moisture content of 12-14%. This indicates that the artefacts are placed in a healthy room, but with easy access of damp air.

The observation of the values of radiation stresses that it should be desirable to replace lamps because they do not meet safety standards; modern lighting systems could assure a more appropriate illumination for museums (eg 100-

150 lux).

Entomological monitoring has shown the absence of insect attack in progress.

The xilological survey of the tablets has revealed sometimes a little careful choice of wood because of the presence of knots, ring shake and sapwood. Furthermore, some important informations about the origin of the trees emerge. The origin seems to be related to the Tuscia territory in fact many tablets are made of chestnut wood probably coming from the area.

The state of conservation of the votive tablets seems to be quite good probably due to the environment characteristics. Further experimental studies are in progress to verify if the microclimatic conditions are suitable for a correct conservation of the artefacts.

Environments, strongly influenced by the outdoor climate, require long periods of monitoring and sustained over time, at least annual, for a characterization that may suggest effective systems of conservation and maintenance.

Other aspects, less variable over time, can be evaluated efficiently even with punctual measurements.

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## THE DOMUS AUREA IN ROME: “AN HYPOGEUM MUSEUM”. MICROCLIMATE AND MICROBIOLOGICAL ASPECTS.

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The Domus Aurea in Rome, Emperor Nero's palace dated II century AD, is now a large hypogean archaeological area. It is constituted by halls, rooms, corridors, etc., some of them decorated with precious mural paintings and stuccoes.

High levels of relative humidity and masonry moisture content, in presence of thermal fluctuations and/or air movements cause evaporative and condensation phenomena on surfaces. These conditions favour biodeterioration of paintings, in particular residual organic soil matter allows the heterotrophic microorganisms growth.

Due to these critical environmental conservation conditions, the public is allowed to visit only a part of these spaces.



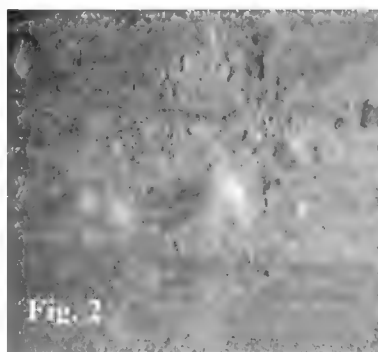
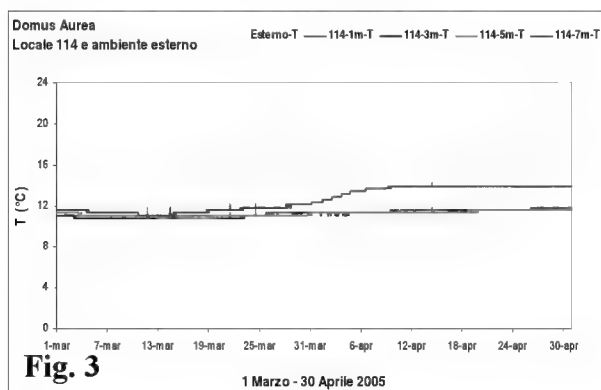
To evaluate the possibility to include in the visit tour two rooms, with frescos particularly well preserved due to a system of air tight doors installed in the '90's, an environmental study was conducted (fig.1). The research has highlighted the inevitability of a thorough control of the environmental parameters and of the number of visitors in the rooms, as it happens in some museum rooms, where particularly susceptible works of art are exhibited.

To determine the climatic and microclimatic conditions of the painted rooms and of the immediate surrounding areas, a seasonal microclimatic monitoring was conducted. In particular surface temperature at different heights has been recorded to evaluate condensation processes, presence of thermal gradients, possibly

linked to the insulation effect of the ceiling covering. The interrelation between microbiological attack on paintings and microclimate behaviors were investigated. The people effect on microclimate and on the airborne microorganisms levels were also analyzed.

The microclimate monitoring has shown different levels of risk linked to the seasonal periods; periods when maximum and minimum differences between the thermal conditions of different communicating areas occurs were highlighted. This information will have to be taken into account to set up the experimental visiting program, as it is necessary to determine the minimum perturbation on the microclimate of the rooms.

Bacterial (Streptomyces) and fungi colonization on surfaces have been detected in relation with seasonal thermal increase; the attacks were localized



in the higher level of wall, in accordance with the microclimatic results (figs. 2 and 3). The results of aerobiological monitoring have shown a considerable raise of microbial diffusion in the air in relation to presence of people; micro-fungi greatly prevail over bacteria. After the restoration intervention, the values of microbial charge in the air are reduced but remained over a risk level. Some isolated fungi have been identified as dangerous for mural paintings.

## MICROCLIMATE MEASUREMENTS IN THE NAPOLEONIC MUSEUM IN ROME: A PILOT STUDY

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**Keywords:** microclimate, lighting, indoor conditions

### INTRODUCTION

The ground floor of the Primoli Palace in the centre of Rome houses the Napoleonic Museum. It occupies twelve rooms in the ground floor (from I to XII). The collection consists of significant paintings, original manuscripts, Napoleonic relics and family mementos donated to the city of Rome by Count Giuseppe Primoli a descendant of Bonaparte.

The present pilot study intends to characterize the microclimate and lighting (both natural and artificial) in Room IX (entirely located inside the Palace) and in Room XII, to determine whether the collections (mainly paintings and aquarelles) may suffer from inadequate environmental conditions. A discussion of lighting conditions is also provided.

### 1. DESCRIPTION OF THE ROOMS

Figure 1 shows the museum plan and the location of the rooms under study (Room IX Room XII).



Figure 1: MUSEUM PLAN

Room IX (Figure 2) is characterized by three windows on the internal court, two entrance doors, four oil paintings and five water colours opposite the windows. Fourteen halogen lamps with diffuse filters, as the lighting system, are present.

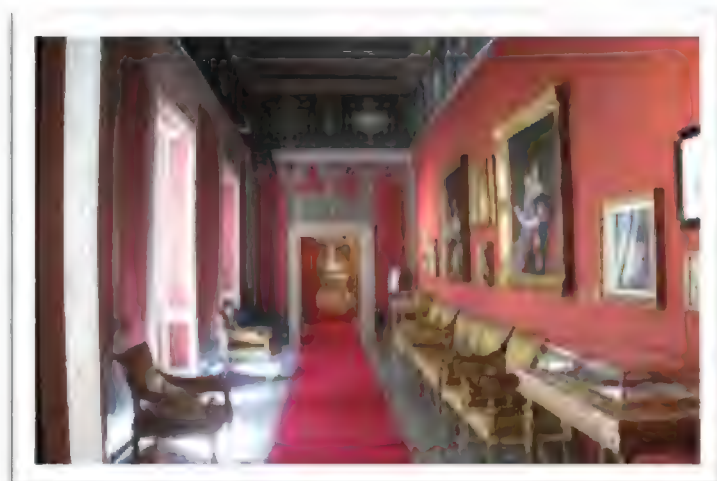


Figure 2: ROOM IX CARLOTTA AND ZENAIDE BONAPARTE

In Room XII (Figure 3) there are two windows on the outer side, two entrance doors, six oil paintings, two water colours, one lithography, one tempera on silk, one pencil drawing on paper, one pastel painting. Eight halogen lighting spots (50W each) with diffuse filters are installed.

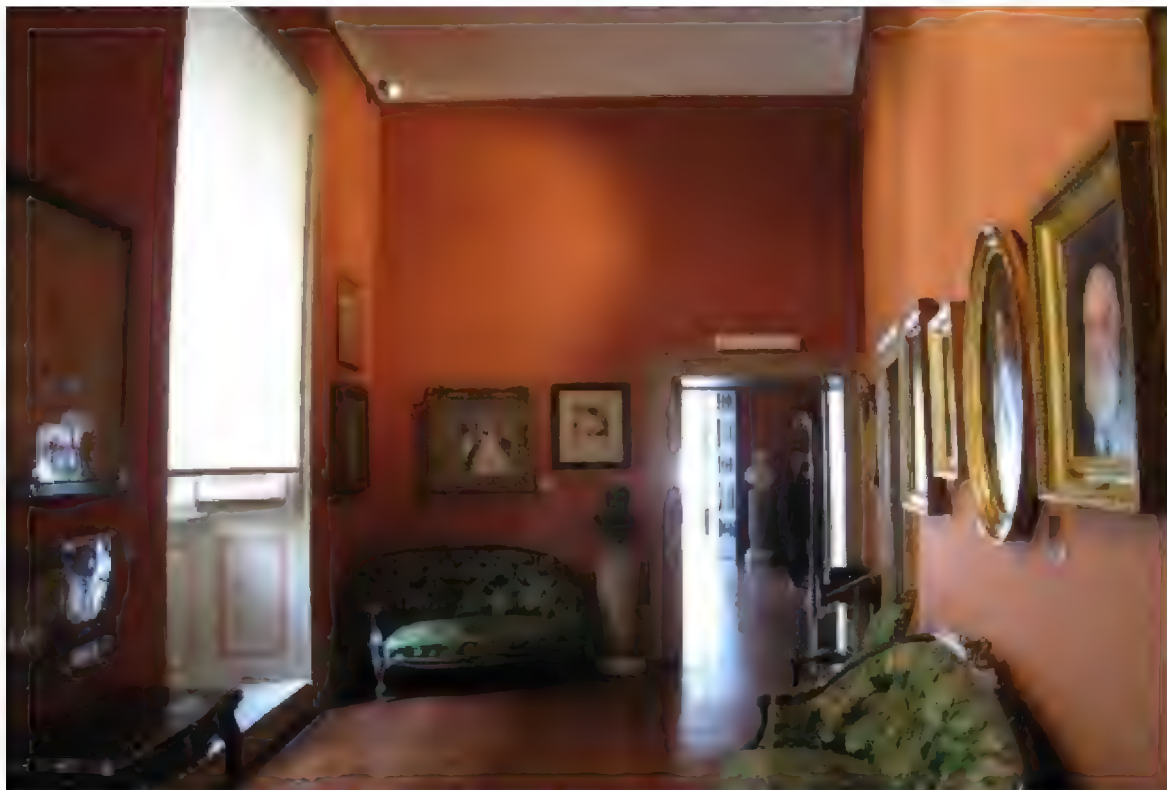


Figure 3: ROOM XII GIUSEPPE PRIMOLI AND MATILDE BONAPARTE

Heating system operated from November to March in both Rooms

## 2. LIGHTING MEASUREMENTS

Lighting measurements (both natural and artificial ) were carried out in fixed point, named A, B, C, D (Figure 4) of each painting. Illumination ( $E$  in lux [ $\text{lm}/\text{m}^2$ ]), UV radiation (315nm-400nm, in  $\mu\text{W}/\text{lm}$ ) were measured by Delta Ohm photometer (model HD 2302.0) with uncertainty of 20%. In addition Illumination Uniformity ( $E_{\text{max}}/E_{\text{min}}$ ) was also determined.



Figure 4: Giuseppe Primoli drawing (1920)



Three field campaigns were performed at different time of day (9:30, 13:30, 17:30 local time, LT) aiming at a characterization of natural illumination, artificial illumination and natural with artificial illumination in both Rooms.

### 3. THERMO-HYGROMETRIC MEASUREMENTS

Measurements of internal temperature ( $T_{in}$ ) and relative humidity ( $UR_{in}$ ) were taken with 1 hour sampling using thermo-hygrometer sensors with automatic data logger (uncertainty  $0.3^{\circ}\text{C}$ ,  $0.3\%$ ). The period under study was: 3 November 2008 -31 July 2009

Hourly averages air temperature ( $T_{out}$ ), and relative humidity ( $UR_{out}$ ), provided by CRA-CMA Rome meteorological station in the city centre, were also taken into account.

### 4. RESULTS

#### 4.1 Illumination study

The results derived from illumination measurements are summarized below.

##### *Water colours*

Natural lighting: E range = 6 –181 lux in Room IX; E range = 8 - 69 lux in Room XII.

Artificial lighting: E range = 30-170 lux in Room IX; E range = 22-80 lux in Room XII.

Natural and artificial lighting: E: range = 100-224 lux in Room IX and E range = 60-240 lux in the morning in Room XII.

##### *Oil paintings*

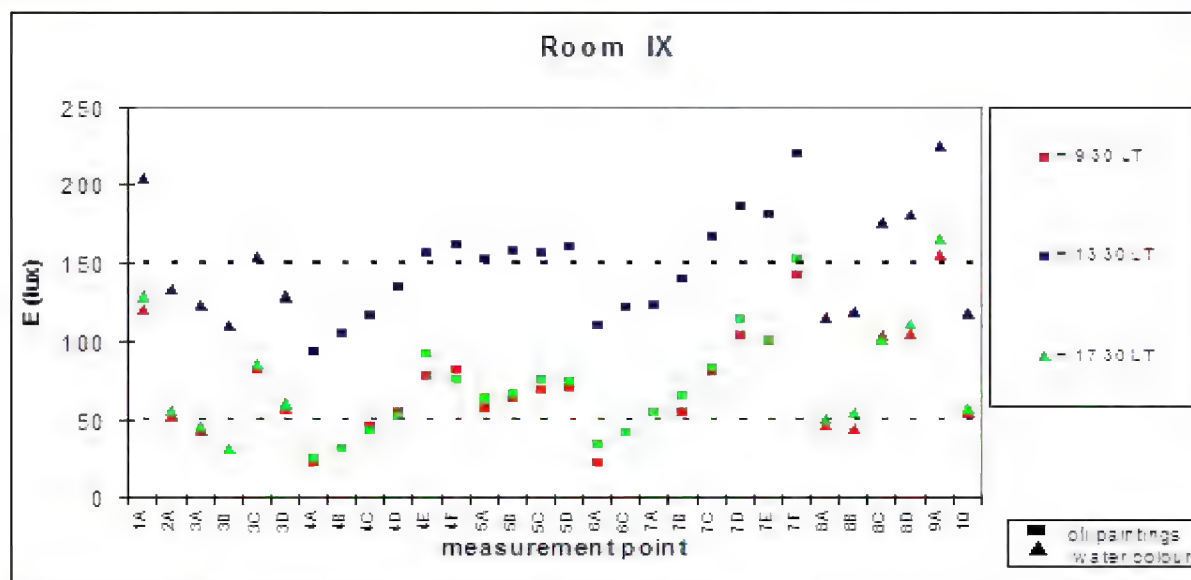
Natural lighting: E range = 6-170 lux in Room IX; E range = 80-85 lux in Room XII.

Artificial lighting: E range = 19-178 lux in Room IX; E range =12-126 lux in Room XII.

Natural and artificial lighting: E range = 150- 220 lux in Room IX; E range = 34-105 lux in Room XII.

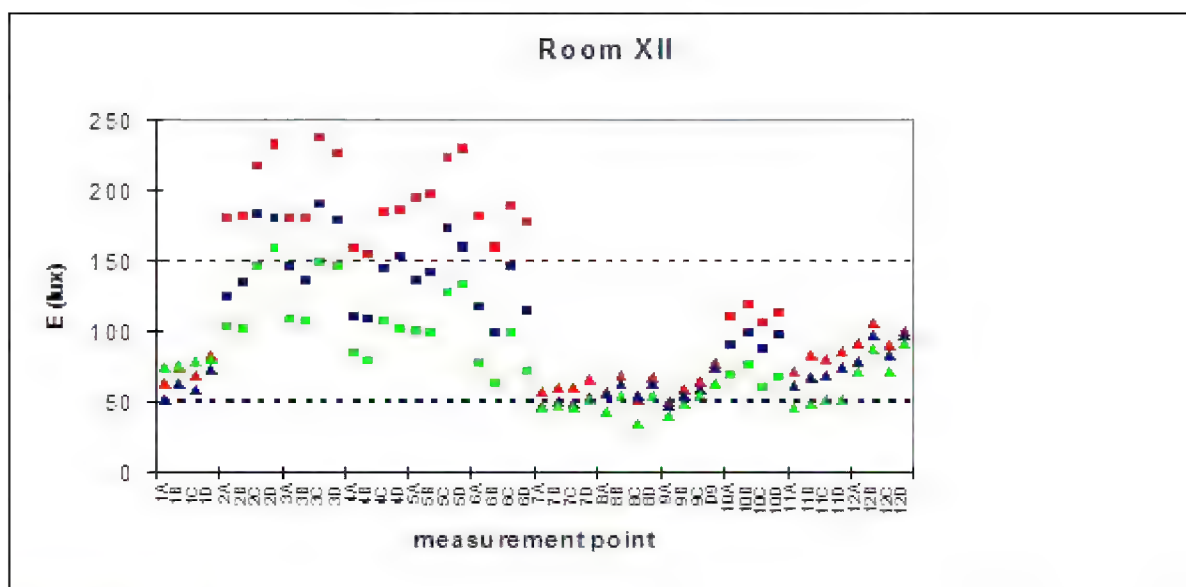
Illumination uniformity  $>2$  in both Rooms; UVA radiation is within the threshold values in both Rooms.

Figures 5 and 6 show the temporal behaviour of lighting (natural and artificial) in Room IX and Room XII, respectively. It can be noticed that in many cases the measured values are greater than those recommended by UNI 10829 (150 lux for paintings and 50 lux for watercolors ).



**Figure 5:** Room IX, Lighting (natural and artificial) at H: 9:30 LT (red); H: 13:30 LT (blue); H: 17:30 LT (green). E threshold of 150 lux for oil paintings and of 50 lux for water colours are plotted.





**Figure 6:** Room XII, Lighting (natural and artificial) at H: 9:30 LT (red); H: 13:30 LT (blue); H: 17:30 LT (green). E threshold of 150 lux for oil paintings and of 50 lux for water colours are plotted.

#### 4.2 Thermo-hygrometric study

The results of thermo-hygrometric study for cold (November –March) and warm period (April-July) are summarized below in terms of mean temperature and its standard deviation, and minimum and maximum relative humidity values.

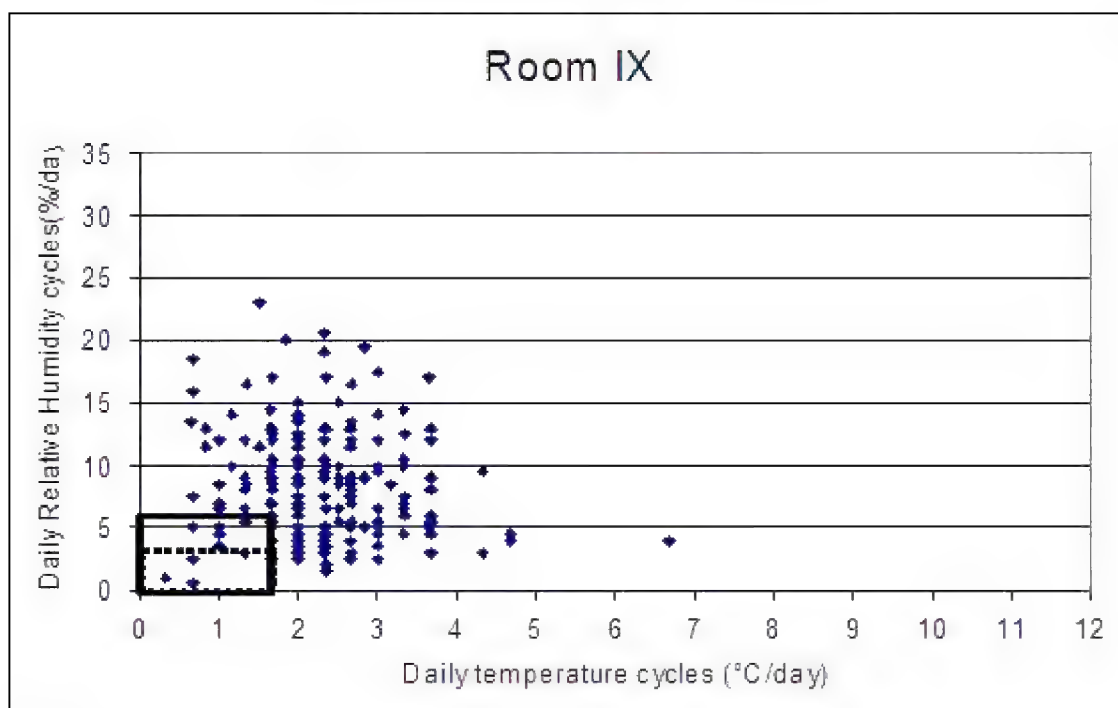
Room IX, cold season:  $T = (22.9 \pm 1.1)^{\circ}\text{C}$  and UR (18%-56%); warm season  $T = (27.3 \pm 2.5)^{\circ}\text{C}$  and UR (23%-62%).

Room XII, cold season:  $T = (22.7 \pm 1.6)^{\circ}\text{C}$  and UR (10%-67%); warm season  $T = (26.5 \pm 3.3)^{\circ}\text{C}$  and UR (25%-62%).

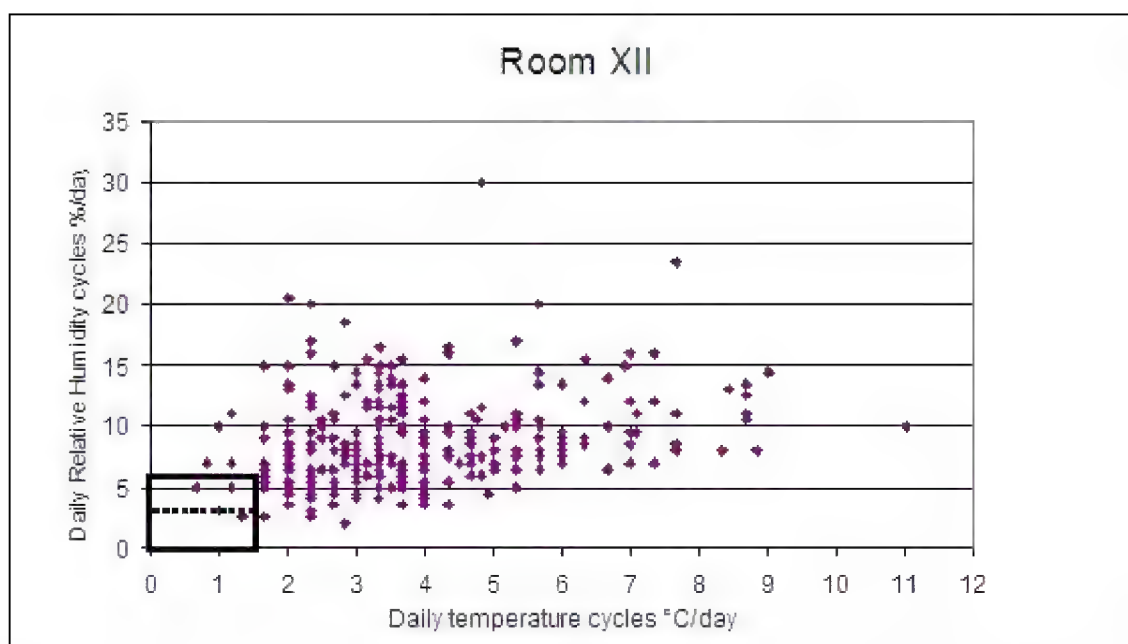
In addition it was observed that external thermal conditions affect the internal temperature of Room XII ( $r = 0.73$ ) during warm season, even more than in Room IX ( $r = 0.57$ ). A moderate correlation was found between UR<sub>in</sub> and UR<sub>out</sub> in Room XII during both seasons ( $r = 0.49$ ;  $r = 0.42$ ) and only in Room IX ( $r = 0.40$ ) during warm period.

During the cold period the heating system effectively controlled the internal temperature ( $>17^{\circ}\text{C}$ ) and both Rooms experienced low UR levels.

The scatter diagrams of the daily cycles in relative humidity and temperature in the period under study (3 November 2008 -31 July 2009, 1 hour sampling) are reported in Figures 7 and 8 respectively. The two safety areas indicated by Italian Regulation 10829 (1999) are also plotted: thick rectangle is related to oil paintings ( $0-1.5^{\circ}\text{C}/\text{day}$  and  $0-6\%/\text{day}$ ) while dotted rectangle ( $0-1.5^{\circ}\text{C}/\text{day}$  and  $0-2\%/\text{day}$ ) concerns water colours.



**Figure 7:** Room IX, Scatter diagram of the daily cycles in relative humidity and temperature in the period under study. The two safety areas indicated by Italian Regulation 10829 (1999): thick rectangle for oil paintings ( 0-1.5°C/day and 0-6%/day) and dotted rectangle for water colours (0-1.5°C/day and 0-2%/day) are reported



**Figure 8:** Room XII, Scatter diagram of the daily cycles in relative humidity and temperature in the period under study. The two safety areas indicated by Italian Regulation 10829 (1999): thick rectangle for oil paintings ( 0-1.5°C/day and 0-6%/day) and dotted rectangle for water colours (0-1.5°C/day and 0-2%/day) are reported

## **CONCLUSIONS**

The preliminary investigation on lighting and microclimatic conditions showed that lighting (mainly natural light) exceeded the threshold values in both Rooms. Such situation could be mitigated with the use of curtains and/or the partial use of electric lighting. The internal microclimate resulted too warm during the summer period as a consequence of high external temperatures, mainly in Room XII. Relative Humidity was low in both Rooms during the day, while remaining relatively stable during the night. Switching off the heating system at night, and when the museum is closed, is the main cause behind the daily temperatures and relative humidity cycles falling outside the safety area, during the winter. Significant variations in temperature were also observed during the summer when the windows were kept open.

The next step will analyze a full year data record to characterize typical cycles which occur repeatedly, to try to determine more realist safe region that should be respected for temperature and relative humidity control (Camuffo et al., 2004), in accordance with UNI 10829 (2002).

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## SESSION D3 - ECONOMICS AND TOURISM

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### SIGNIFICANCE AND DEVELOPMENT PROSPECTS OF THE ECOMUSEUM

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*University of Catania*

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<sup>2</sup> Giuppe Reina is the author of §§ 4, 5, 6.

#### 1. Preface

The significance and the classical model of the museum have undergone profound changes. In the classical view, the museum is a wrapper closed, an elite place, exhibition centre, a still building. In the modern view museum is characterized by greater flexibility and adaptability to complex societies, to the strong dynamism and strong sense of identity that characterizes the different communities in our time. The same type of museum is enriched with new realities. Among them worthy of importance is the eco-museum. Born in a pioneering way few years ago, only recently it has developed in the world with a rapid spread. Recently in Italy it has so much grown in many regions that some have already legislated while others are doing so.

The modern concept of eco-museum examines various themes by making a modern synthesis. The themes of eco-museum are the concept of landscape, the value of local identity, the concept of sustainable development, the concept of *melieu*. It's important to create the conditions for finding a common language and especially to grow a real cultural project in different regional situations.

A Project aimed at discovering and defining new workspaces, new values, new stimuli, new targets that can revive and nurture the local realities and make them aware of their cultural and natural heritage. Moreover it is important to build on the awareness of reconstructing local identities perspectives and strategies for sustainable and lasting development. The idea of ecomuseum moves into this direction. Its wider and wider institutionalization can represent an innovative and advanced stage in the process of enlargement and rooting of this experience in areas that lack ecomuseums and still have not legislated on the subject. As an example of landscape protection and enjoyment of its environmental and historical values.

#### 2. Meaning and relevance of the concept of landscape

In the current cultural and scientific discussion the landscape is becoming more and more important and significant. A first explanation can be given by the growing attention to environmental issues and identity. Actually there is even another explanation which is given by the growing perception that the quality and diversity that characterizing many landscapes today and in the past are declining, and as direct consequence, the people quality of life. These general opinions on the benefits and quality of landscapes emphasize a way of thinking that is profoundly different from that of previous years because today it is preferable to pay attention to a broad landscape that embraces the whole territory. The concept of landscape is now given a wider and innovative meaning. Indeed it is characterized by the presence of resources and natural elements, that is marks left on the territory by the human being in the slow evolution of history. The landscape is assumed, therefore, as a cultural heritage that in its global value combines historical goods, monuments and natural features of the territory. The identity and the landscape recognizability are thus key elements of the quality of places and are directly related to training and enhancing the quality of population life. The landscape is, thus, given the critical role of enhancing individual and social welfare and of raising the people quality of life, contributing to the preservation of their identities. The more developed and shared is the sense of people belonging to places, the more rooted in the landscape is their sense of identity, which will tend to protect. It is clear to everyone that the way we think now the meaning of the landscape, its importance and its social, cultural and territorial role is very different from the way of thinking in 1939. In that year due to the Law Bottai No 1497



"Protection of natural beauty" it started to define and legislate in our country, with an initial demonstration around the theme of landscape protection and landscape planning. According to the new conception the landscape is composed of "things" and rare, separated and confined "location", which are not related to the whole territory but only to some of its parts. These parts have to be – using the language of the time - "substantial characters of natural beauty or unusual geological features," being "of uncommon beauty," have to own "a characteristic appearance with an aesthetic and traditional" character of "scenic beauty" or "natural framework". A "visual" and "aesthetic-literary" conception, according to which the categories of value only relate to the "beauty" and "uniqueness" of objects or places. From it follows, therefore, that the primary purpose of plan is reduced only to that of exercising a detection of these rare heritage and to promote and establish a protection and an uncertain safeguard through a "government" entrusted exclusively to the State through the Ministry of Culture and Environment.

But we must also bear in mind what and how many news, activities, developmental milestones, upheavals and changes in cultural paradigms and social collective purposes presented themselves on the scientific-cultural stage in the same period - think of the explosion of environmental issues, the awareness of the development limits and the consequent focus on sustainable development - which could not fail to engage and be reflected also in the question of the landscape.

Cultural evolution established in Europe whose pivotal moment was the European Landscape Convention signed in Florence in October 2000, introduced new elements of attention to the landscape that have enhanced its value: the landscape is no more seen only as a place of excellence and cultural heritage of the country but also as a great resource for sustainable development, and fundamental to the individual and social welfare.; It can be said that the largest contributions to the renewal of thought firstly come from the critical rethinking began by the geographers on the foundations and limits of their discipline. Crucial steps that can not be ignored, should be attributed to the rediscovery and the late critical rethinking on the work of Eric Dardel *The man and the earth. Nature of the geographical reality* that dates from 1952, to the fundamental text of Giuseppe Dematteis *Metaphors of the Earth*, which has subjected the geographical discipline to a rigorous epistemological critical reassessment, to the action of the magazine *Hérodote Italy* (Italian edition, directed by Massimo Quaini, of the namesake French magazine directed by Yves Lacan).

Moreover the contributions dating from the great disciplinary and cultural change made by the *geo-history*, founded by Fernand Braudel and increased and scattered by the Annales school and by the intrusion of history in social knowledge as a measure of the world, cannot be forgotten. It is fundamental into this direction the work carried out by Lucio Gambi in Italy who, making a strong critic of the geographic knowledge - geography depressed region - has managed to raise it, with his *A geography for history*, to a broader level of knowledge, in which it is easy for us to find ourselves. It is easy to recognize that due to the work of geographers a new concept of landscape comes out. "Landscape- writes Dematteis – is like an image written on the soil of a society and culture". Therefore a new problem to "decipher the hieroglyphs of the earth" (Dardel) appears. From these studies and guidelines new theoretical possibilities but also new applications are emerging.

### 3. Design ecomuseum

The rapid changes which involve the current society, the rapid transformation of places and ways of life often puts at risk the survival of local and regional identity. This is an opportunity for scientists, technicians and operators in the sector, but also a stimulus to reflection on how to define the resources, processes, and sustainable strategies that aim to identify, characterize and evaluate the landscapes of the Mediterranean, in order to protect, promote and enhance the landscape quality. To govern the transformation of landscapes, now a prerequisite is to formulate strategies for preservation, management and planning based upon the founding principles of sustainability and operations conducted by interdisciplinary synergy. Addressing a project on "Urban Act" means taking a difficult path within a variety of issues, actions, processes. A even more complex path when you consider that it directly touches the intimate and emotional dimension that develops in the relationship between the people and their everyday life spaces. Traditions, languages, customs, permeate an area that too often is direct and exclusive jurisdiction of the institutions, who through urban policies give a clear line to the city government. The time of the story, the exchange of experiences at narrative content, seems no longer of interest or at least is no longer sufficient now. Ten years of comparisons and the running of "best practices" of communication and meetings, appear to have developed a shared vision about the most appropriate ways to foster local development. The big question emerging now is not only "do", but especially "how" to do so. These assumptions are essential to understand what relationship may exist between local identity and landscape in the ecomuseum design approach proposed in this contribution. The design of the Ecomuseum is characterized by a programmatic approach "BottomUp", in which the various entities which are expression of the concerned territory (local institutions, representatives of economic groups, unions, associations and ordinary citizens, etc.). - cooperate in the drafting and implementation of virtuous paths of urban policy. More specifically, the eco-museum can be described as a reality oriented to promote the socioeconomic development of the territory, through promotion and networking of local cultural dynamics, creating synergies with the tourism industry and economic environment and the attention promoting the logic of sustainability. It plays a valuable role in spreading awareness of belonging to a cultural context, whose peculiarity is well to emphasize and protect, in a logic of confrontation and openness.

An Ecomuseum has among its tasks to identify, understand and convey its property, tangible and intangible, in time and space. To do this, it considers the local heritage as its object-subject and promote:

1. detection: reconnaissance, inventory and cataloging.
2. knowledge: analysis, study and synthesis.
3. transmission: protection, participation and communication.

The configuration and focus on environmental and cultural elements that characterize the area help to define a true cultural district from which to carry out activities of safeguard and of identity enhancement. The aims to pursue are the development of networks of associations and companies operating in the same sector and the strengthening of sub-systems. This should be pursued with greater determination, at least as regards the capacity of the sector to grow in quality and provide effective responses to the major "nodes" of production and marketing of cultural character.

The perspective within which to place knowledge, preservation and enhancement of local heritage is certainly not in the sense of making the territory a museum, if that means refuse its amendment or oppose to a development perspective and transformation. The aim instead is to identify and understand the many layered values expressed by a territory and to preserve - as possible - their distinctive characteristics even when radical changes are planned and implemented, to select the items who are intended to be preserved for the future generations. In order to keep the sense of where they happen to live, it is necessary to spread the tools necessary to interpret the meanings and values inscribed in the signs of a past more or less close, more or less, but still significant and worthy of continuing to be perceived and understood, made obvious when no longer self-evident.

Therefore this work lies in a perspective of active protection and shared heritage area, in a perspective capable of promoting development which respects the historical character of the area. The basic concept of the Eco is not of collection, but that of "narration" The territory tells the story of its culture, highlights the "file rouge" of connection, the expression of cultural layers of places. The Eco-Museum catalogs and protect the places, proposing them as an archive of reading for the knowledge of the territory. The redefinition of the concept of museum is required. Now the exhibition space is no longer limited to a single building, but embraces the whole area of reference in relation with human activities. Therefore a museum has to be highly integrated with the territory, expression of a community and aimed at the social, economic and cultural development of both. A museum that consists of a comprehensive system of fixed stations and routes, identified by previous Focus Groups with various local stakeholders.

Such a structure called "eco-museum" is the educational and informative exhibition centre and the metaphorical main gateway to visit territory. The creation of the interface between government and citizens guarantees in shorter time better performances in the construction and management of urban plans.

As a Recent phenomenon spread throughout Europe, the eco-museum is in the midst of a phase of experimentation. The first difficulty of the Eco-Museum is precisely to explain what it is, due to the multifaceted character that this reality is taking in different places in Europe. The Eco-Museums have different types of forms: ethnographical museum, anthropological museum, rural life, artisanal and industrial landscape museum. It is oriented to the preservation and enhancement of all the tangible and intangible values of the territory. The rich web of connections and relationships that unites them constitutes the "local heritage."

#### **4. Brief history and articulation of ecomuseums**

The origin and development of Ecomuseums first in Europe and afterwards in Italy, fits into a precise historical and museological context that the 1970s when the concept of "traditional" museums (if this term may be used to indicate a category ideally homogeneous) undergoes a major reorganization by the international museological community concerning, first of all, the relationship between the museum and its public. These are years in which the attention of museum curators focused on the need to democratize the museum, making it a centre and instrument for comparison with a potential audience larger than the usual, educated elite, able to access the museums content, decoding its complexity. In 1971, Duncan F. Cameron opposed the concept of "museum forum" to a "museum temple" which evidently refers to the concept of forums: the exchange and sharing of opinions and thus an ideally open space. In the same year, during the General Conference of ICOM in Grenoble, John Kinard defines the "museum district" a place that emphasizes people rather than collections and aims at being useful to the community. In France in this context of evident intellectual ferment many initiatives developed that, according to Georges Henri Rivière, should be of public utility and, at the same time, the museum should relate to the territory in reference to cultural heritage as well as to those of the environment. The concept of eco-museum has been further developed by Hugues De Varin, Director of ICOM and authority of local development, who first used the term eco-museum and has marked the evolution acclaimed as a social process, aimed at the local community that interprets heritage as a key to its development; characterizing, as De Varin writes, three core concepts: the territory, population and wealth, as opposed to components identified in classical museums: collections, property and public. These are the three essential components of every Ecomuseum, which constitute the substance, content and method of work:

1. The territory, because the eco-museum is not a building or a place, but is spread systemically throughout the entire space, representing and making the characteristics, the landscape, history, memory and identity more visible.
2. Population, because this is the true subject-object of the Ecomuseum. Only its participation justifies its existence,

because it is the succession of communities and populations in space and time which created the landscape and heritage of an area. In order to ensure that participation does not remain merely a slogan and is not confined to purely representative forms with no real power and effect, it is essential to establish, in what form and at what levels you want to involve the population.

According to the experience of many Ecomuseums the following levels must be preserved:

- the decision-making level.

It has been respected in the developmental process of Ecomuseums. Now the question of what form and measure the population should enter the management of Ecomuseums needs to be prefigured and proposed.

- the level of collection and preservation.

The collection of objects, preservation of artifacts and sites, unlike traditional museums, is based largely on the cooperation of the population, through donations, loans, open houses and rural buildings, preservation of old tools and environments in their original condition, makes a fundamental contribution to the resources of the Ecomuseums.

- the level of restitution and testimony.

If the population is involved in the donation, it is only right that they also participate in the restitution phases (including the form and communication projects) that can involve the history of objects, conservation of memory, traditional uses, know how, the direct testimony of donors and the entire community.

- the level of reception, information and management.

If the Living Museum (**Ecomuseum**) wants to reflect the community it is normal for its members to represent and take charge by serving the public, by telling their experiences and their vision in a direct and unfiltered way, contributing to making the information and their identity real and in this way directly managing their own resources.

3. The third component of the Living museums is made up by the assets (**resources**), not as a part (such as art or science or archeology or ethnographics) but for everything that makes a community worthy of being called such, or whatever our forefathers left us to pass on to our own children.

This sense of heritage, which is the object-subject of ecomuseums, can only be very large: it is one of the territory, the landscape, the environment, the beautiful and the ugly, public and private, the material and the invisible, the cultural and historical, that which is memorable and repressed and everything that the community (directly or by its representatives and its forms of expression) has attributed sufficient value.

The eco-museum, therefore, has a task compared to the past - that is, until yesterday - (identify, know) and the future - that is, from tomorrow - (transmit). The most accredited and concise definition of the concept of eco-museum emerged from the international workshop "Long Networks - Ecomuseums and Europe" held in Trento in May 2004: "The eco-museum is a dynamic process by which communities preserve, interpret and exploit their resources in function of sustainable development. The eco-museum is based on a pact with the community." The many initiatives have thus encouraged the emergence of the identity of local communities and begun processes of economic development through the "sustainable" preservation and reinterpretation of particular aspects of cultural and environmental heritage, capable of capturing the dynamism of society and local cultures, increasing the value of the area rather than consuming it.

## 5. The European Landscape Convention

Planning ecomuseums certainly represents a strategic tool to boost the values of identity, which find expression in the landscape as a evolutionary product of the interaction between natural and cultural factors, in the direction indicated by the "European Landscape Convention, signed in Florence in 2000. The Convention stresses the importance of the landscape as "element of identification and connection of local communities with their places of reference." The Convention bases its ideology on two basic principles:

a) the landscape must be legally recognized and protected regardless of the concrete value actually assigned. The argument in which the landscape can be protected legally only when it assumes a particular value (which excludes protection when this value is not found) is superseded by the Convention. The most important consequence of this principle is that when a state adheres to the principles of the Convention it must acknowledge scenic importance to the whole territory under its sovereignty.

b) taking into account the essential subjective dimension of the landscape, the population must be actively and continuously involved in the decision making process relative to that which concerns the landscape. Depending on the democratic, economic and administrative efficiency, the landscape, except in cases where a higher interest is detected, must be protected, administered and/or shaped (**fashioned**) by public decisions taken considering the

population. As far as landscapes are concerned, the Convention clearly indicates that public responsibility should, preferably, be decentralized to a local level as far as the principles of subsidiarity and autonomy are involved. Consistent with these principles, the 5th article of the Convention commits the parties to recognize landscapes judiciously as a vital component of people's living environment, an expression of the diversity of a shared cultural and natural heritage and foundation of an identity and must therefore preferably be decentralized at a territorial level. Regarding the issue of awareness, the Convention is concerned with preceding any public activity concerning landscapes, be it cognitive or operational in nature, by activities of appreciation of the landscape's value by the civil society, private organizations and public authorities, its role and its transformation. Once informed of the risks, limitations, contrasts, benefits and values of landscapes, these social categories are more likely to be able, when solicited, to communicate to the competent authorities their aspirations (**desires**). Taking account of these aspirations, the authorities will make the necessary decisions.

## 6. The code of cultural heritage and the future of eco-museums in Italy

The Code of cultural heritage and landscape is the most important legislative instrument in the evolution of Italian law following the signing of the Convention by the Italian Parliament.

The article 135 on the regions landscape planning, states that such planning should cover the entire region, thus extending its scope throughout the country; the Article 144, relating to advertising and participation, provides that institutional consultation and participation of stakeholders and associations, formed to protect the common interests, are ensured in proceedings for approval of landscaping plans.

The recognition of the active role of citizens in decisions affecting their landscape can offer them the opportunity to better identify with the lands and cities where they work and spend their leisure time. If the relationship between citizens and the places where they live is strengthened, they will be able to consolidate both their identity, the local diversity and regional level in order to achieve in terms of personal, social and cultural development. This realization is the basis for sustainable development of any area in question, because the quality of the landscape is an essential element for successful economic and social initiatives, whether private or public.

Therefore the construction of plans and projects "from below" broadens the scope of interest in the social perception of landscape as a living environment. The quality of the landscape is no longer recognized through historical-documentary and aesthetic-visual analysis or through ecological and systemic-relational analysis, but also and especially through the social dimension, the rediscovery of "affection" towards the places of individual and collective memory and of the "culture settlements." The many appeals of the European Landscape Convention to an increasingly active role of population, implies also the comparison, the dialogue between the "disciplinary knowledge" of experts (engineers and technicians in general and researchers, each for their own skills) with other "knowledge", derived from listening to local communities in a process of mutual learning and interpretations. Communicating with the inhabitants and between inhabitants to understand, to reconstruct a "shared image" of the city, the neighborhood, to search for the deeper meaning that each community assigned to the places of life and relationship, requires a time that not always is possible to spend. I would say that the "time factor", which powerfully haunts our existence, is a major constraint. Therefore planning and building procedures consider normative references exclusively, follow models already tested elsewhere, never speak to the richness of "that" context, to whom, living there, is an expert in "those" places. Issues related to urban change and in particular to retraining operations (environment, suburbs, brownfield sites and urban spaces) are increasingly linked to the communicative and participatory methods. However in more of a reality they are successfully tested inside building plans (structural and / or strategic) and sectoral issues (mostly related to issues of localization of activity with high impact or low-grade for the population, such as waste incineration plants). What is certain is that the eco-museum may be a response to the need for "a sense of territory" to affirm identity, diversity, specificity, which are incorporated as a cultural pattern that combines the elements (nature, culture, tradition, history, architecture, religion, language, food and wine) of a place. But it is also a key to enter the landscape, and perceive it as an archive of cultures in the historical succession, to learn to read and understand the signs, vocabulary, morphology, syntax, grammar of places, to discover and stimulate interest and knowledge capacity.

The future of eco-museums is in the local communities; The actors involved are not only institutions as their important driving force must be accompanied by a wider involvement of citizens: local administrators of different levels, cultural associations, interests and lobbies. The eco-museums must find their place as actors in the scenario of local governments and this requires, in addition to a specific attention to this problem, the construction of a recognized and authoritative status. Waiting for a "legal system" which would cover the whole country, many regions in the last fifteen years have legislated on many initiatives, starting from Piedmont, the Province of Trento, in the Autonomous Region of Friuli Venezia Giulia, Molise, Lombardy; others such as Puglia, Sardinia and finally Sicily submitted bills. It should be noted that the first measures did not show the most important and unique objectives of eco-museums - perhaps they could not do that at the time, but today is a necessity that can not be postponed - perhaps: a commitment to making citizens more aware of the value of local heritage with a participatory approach. From this point of view, the latest laws are very explicit from the first article, firstly when they recognize as a perspective of the ecomuseum to "guide the future development of the territory in a drive for environmental economic and social sustainability, for responsibility and participation of public and private actors



and the entire local community ", secondly when they detect as one of the objectives of the ecomuseum to reinterpret" in dynamic-evolutionary key the historical and cultural roots of communities". This is a very important aspect because it is on this ground that the policies for the cultural heritage can be coordinated with town planning and land management, and - contributing to increase the value of this - play a decisive role for the benefit of economic development, aimed first of all as the growth of inhabitants welfare. In this way the every day reduction of biodiversity and open and agricultural land can be curbed (with an increase in housing standards and land consumption increased tenfold compared to twenty years ago), supported by most of the plans. In this way the landscape governance (or management as you like) is a "mirror of a community "as in the intuition of H. Riviere and the intention of the European Convention. The fate of ecomuseums is in the hands of the Italian regions and the salvation of a large part of our territory is through its proper foundation.

# MUSEUM ORGANIZATION AND LOCAL SOCIO-ECONOMIC DEVELOPMENT: A COMPARISON BETWEEN ITALY E SYRIA

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## Abstract

In the last years, there is a growing expectation that Arts and Antiquities museums play a relevant role in the socio economic development process at the local scale. In their strict notions, as institutions originally meant for conservation and research purposes, museums are not *naturally* bent towards producing direct economic benefits. But indeed, as far as their (local) public increases and they become an important attraction for tourists, their role set shifts. An increased and reorganised museum activity can indeed create or sustain a direct or indirect chain of production of goods and services, and this means generating income, jobs, and a better quality of life. And that can be enhanced by a specific strategic planning. We discuss here two recent experiences in this field at the regional (NUTS II) level, concerning the Italian Region of Latium and the Syrian Region of Idlib.

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## 1. A strategic approach to the problem

This presentation is centred on *strategies*, intended, in the technical planning sense, as coherent and consistent set of (material, financial, organisational, etc.) means devised and arranged in time, space and relationships for the attainment of a specific goal which otherwise would be hardly reached. The strategies that are considered here concern possible way to assign to cultural resources (namely, museums) a pivotal role in local socio-economic development.

A good starting point is the observation that the original role of Museums had little to do with socio-economic development. Cherished Wunderkammer of wealthy antiquities collectors during the Renaissance, treasured repositories of archaeological findings or artistic objects demanding the utmost care and attention from experts and scholars, magnificent exhibitions of booty and conquest of the Imperial Powers of the Colonial age, places where the national or ethnic identity is built and represented by means of material culture, museums have indeed produced value, but of a social, cultural and symbolic sort. In economic and financial terms, they mostly have been conceived – even when very efficiently administered – as a *merit good*, i.e. a (public) cost to be borne in view of the non economic benefits they would provide to the public. This vision entails many consequences, but we only mention two: i. historically, museums did not necessarily address a vast public; ii. they were not designed as profit-making or economically self sufficient organisations.

In turn, this implies that museums are not *naturally* bent towards producing local development. But indeed, as far as their (local) public increases and they become an important attraction for tourists, their role set shifts. An increased and reorganised museum activity can indeed create or sustain a direct or indirect chain of production of goods and services, and this means generating income, jobs, and a better quality of life. And that can be enhanced by a specific strategic planning.

## 2. An Italian experience

It is only at the end of the Eighties that Italy implemented – particularly in the South - policies and programmes aimed at fostering economic development via interventions on the cultural heritage. The first steps, not very successful, tried in a rather mechanical way to link (youth) employment with projects of massive inventory of hundreds of monuments and sites which at the time were not Listed. In the following decade, also thanks to the additional resources stemming from the UE Structural Funds and the growing role of Regional governments, local development projects have been increasingly oriented on culture (mostly museums and sites). In a first stage, this was almost exclusively tied to heritage, and functional to tourism development strategies (2000-2006), while from 2007 onward, there was a shift towards a broader acception of culture (including the performing and visual arts, multimedia, etc.) and a strategy aimed at improving the quality of local life and attractiveness of regions.

### 2.1. Local cultural resources for local development

In the same perspective, in 2005, CUEIM<sup>1</sup> completed a study aimed at the construction of a socio-economic development strategy for the Latium Region, based on “peripheral” cultural heritage, i.e. upon a network of small municipality-owned museums (CUEIM, 2005). I was part of the project working group.

Three strategic approaches were proposed about museums:

- museum as reparation
- museum as network
- museum as agora and itineraria.

The first strategy tends to reconstruct the vital links existing between the objects collected in the museum and the surrounding historical and social milieu. What is inside is connected with what is outside.

The second strategy, based on the idea of complementarity, tends to establish similar links between different museums in the same region or area.

The third strategy is based on the idea that, in addition to its core cultural services, a museum must also play a role as special space in the city or village, for pause and rest and sociality.

The project covered the entire stock of over 500 non-State sites and museums of the Region and proposed their functional re-organisation in a variety of networks, devised to meet the three strategies, each characterised by a specific cultural *theme*.

*Themes* were selected at the end of a complex analysis of the region. They all feature:

- a high identity value for a specific area or for the entire Region;
- strong local historical, social and economic roots;
- relevant stock of monumental physical capital;
- relevant stock of cultural physical capital in the form of museums;
- relevant stock of natural and landscape capital;
- relevant stock of cultural immaterial capital;
- actual or potential links with one or more elements of the tourism productive chain (arts and crafts, food, sports, etc.).

The study identified a first set of 15 main cultural themes for Latium:

1. The Coast
2. The Mountain
3. The *agro* and its historical Drainage
4. The countryside
5. Lakes and Volcans
6. Rivers and the sea
7. The protected nature
8. The historical ethnic groups
9. Migrants, bandits and shepherds
10. The Saracens
11. The Popes
12. Saints, Shrines, Pilgrims and Monasteries
13. Wine
14. Industrial Archaeology and the Mines
15. The Etruscans.

For each theme, the study identified and assessed the degree of rooting in the local identity and culture, the state of art of targeted socio-economic management, available physical cultural capital in the form of museums, immaterial capital and natural capital to be connected into a system, as well as other elements of the tourism productive chain, such as farm holidays accommodations. On that basis, a specific strategy was proposed.

The path for the enhancement of the local peripheral cultural heritage is oriented by three guiding principles:

- a) interventions must be rewarding from both social and economic sides;
- b) tangible and visible results must be attained in the short-medium range;

c) customer satisfaction and effective management are basic requirements for all interventions.

The main tool for planning, in this context, is a master plan, to address specifically the weakness of the region and to build on its strengths. In the case of Latium, the master plan included the following projects:

- identification and development of concepts for peripheral cultural heritage;
- recovery of the physical capital and improvement of physical access to cultural heritage;
- improvement of cultural access to the heritage;
- development of incoming services;
- restructuring of local transportation.

### **3. A Syrian case. The Idlib Museum**

Renewal of the Idlib Regional Museum is included in the Technical and Financial Cooperation Agreement between Italy and Syria. It aims at improving the space for the important collections of the Italian archaeological campaigns in the region (Ebla, to mention the oldest and most renowned, led by Paolo Matthiae, but also Til Afis, Qminas, Tell Deinit, Tell Tuqan). In that framework, in 2009-2010, I had the task of drafting the first guidelines of a museum management which could serve local socio economic development.

The city of Idlib lies 59 Km from Aleppo at a height of 500 metres above sea level. Idlib is hardly, if ever, mentioned in most international tourist guides, that give instead relevance to the Ebla site, in its vicinities. But it is in the Idlib museums that the Ebla treasures are kept, namely, the over 17,000 tablets

In the present state, the collections are organised with no clear written or spatial indication of priority. And that poses problems to the ordinary visitors, those with little or no specific knowledge of local history, culture and art. With no guided tour, a visit to the Idlib museum today takes no more than one hour and leaves the visitor with the idea that nothing really important is to be found there. Unfortunately, tours or guided visits are not organised by the Museum, and audioguides are not available.

From the point of view of non-cultural services, the Museum is not equipped with cloakroom, a restaurant or cafeteria, despite a nice garden that could accommodate it.

Strategies and actions for increasing the significance and the role of the Idlib Museum in the local socio economic development must take into account both the demand and the supply sides of the cultural resources have been formulated from a triple perspective:

- a punctual perspective, i.e. a perspective centred on the Museum itself, its collections, its present and potential cultural and non cultural services;
- a network perspective, i.e. based upon the creation or strengthening of connections of the Museum with other cultural resources (Museums, sites, etc.) of the region, thus creating strategic synergies;
- integrated perspective, i.e. a perspective involving an interconnected system (a potential tourist district) of elements of tourist attraction, both cultural and non cultural (crafts, agriculture, etc.).

#### **3.1. A punctual perspective**

Two basic prerequisites for any punctual strategy for the Museum are the architectural re-organisation of the Institution and the projects for its new exhibitions.

The actions suggested herein concern the way cultural and non cultural functions of the Museum, as re-engineered through the mentioned renewal, could be best addressed to increase its significance for local, national and international tourism.

To this purpose, the analysis and subsequent recommendations will be logically divided into two main categories: supply-side oriented and demand-oriented.

The supply side concerns all the cultural and non cultural goods and services that the Museum provides or could potentially provide, directly or indirectly, permanently or on a temporary basis, to a complex set of users (in turn, present and potential).

##### **3.1.1. Supply side oriented actions**

Supply side oriented actions aim at maximising the capability of the Museum to work as a centre of specific and general cultural and socio-economic creation of value. In this context, this kind of actions impact on three main areas: a) cultural contents and exhibitions; b) organisation, management and operation; c) basic and additional cultural and non cultural services of the museum.



Fig.1 offers a synthetic list of possible examples of cultural/non cultural, permanent/temporary, direct/indirect activities and services for the Museum.

**Fig.1. – Activities and services of the Museum**

	<b>Permanent</b>	<b>Temporary</b>
	<b>Specific</b>	<b>Specific</b>
<b>Cultural</b>	Collections Permanent exhibitions Documentation Educational material Catalogs and other written material Virtual Museum  <b>General</b> Library Bookshop Conference hall  Cultural (narrow sense) Tourist information centre for the area  Reading area Internet Point WiFi hotspot  Cultural (broad sense) Tourist information centre for the area	Exhibits Conferences Lectures Guided Tours Lessons Courses Multimedial material  <b>General</b> Concerts Theatre Conferences  Other Educational activities
<b>Non cultural</b>	Cafeteria Gifts shop Merchandising	Hosting of social events

### 3.1.2. Demand side oriented actions.

Demand side oriented actions are focused on the beneficiaries of the Museum activity. The planning of this specific strategy requires initially a tentative target setting, to single out the different main components of the demand. Who are the present and the potential beneficiaries of the Museum? What are their characteristic needs and interests that the Museum and its cultural contents could meet and satisfy? A first example of possible categories follows.

- Local/national/Arab/international demand.
- Different age groups.
- Gender
- Education and cultural background
- Individual, couple, family, small groups, large groups.
- One-time/repeated visits.
- Generic/specific demand.

### 3.2. A network perspective

As stated above, a network perspective is based upon the creation or strengthening of connections of the individual cultural resource with other cultural resources (Museums, sites, etc.) of the region, thus creating strategic synergies. The obvious advantage of the network is the coordinated effort to find common solutions to shared problems. Networks can be created on a permanent basis (for instance, a group of Museums can share permanently a common card to replace individual tickets, catalogue formats, or logi, or standard services, or staff training

programmes, and so on) or on a temporary one (e.g. special weeks or monthly circuits featuring special themes, etc.).

### 3.2.1. Supply side oriented actions

As suggested above, a cultural network of sites and museums can benefit remarkably from joint actions to improve the cultural services it offers. In very general terms, the cultural supply is more complete and integrated. From the production of catalogues to the training of both front line and back office staff, from the organization of the physical arrangement of the collections to the combined visits based on selected themes, a permanent or temporary network is a very effective way to cut down costs and to increase the cultural supply. Cultural products and services can be provided in a coordinated way, in similar forms and different contents, or shared, borrowed, and so on. From the strategic point of view, the selection of the type of network to be created is a crucial one. Networks of cultural resources can be based upon homogenous or continuous cultural themes (historical periods, geographic areas, populations, religions, techniques, materials, etc.) or simply on typologies (e.g.: the entire system of the museums of a given area). From the communication and symbolic point of view, a network is by far more visible than a single unit: street signs, banners, posters reiterate the message and point to the different knots of the net, making them evident. Networks may also be created for creating user-friendly services, as in the case of circuit-cards integrating transportation and entrance fees for a group of museums. They also help weaker institutions to be towed by stronger institutions (to this purpose, generally, cards include an attractive site or museum and one or more smaller, less attractive monuments and sites: in our case, at least in an initial stage, the Ebla site could establish a mini network with the Idlib museum, and its admission fee could include the visit to the museum) The strength of the linkage may vary, from very intense, involving heavily the cultural activity of the units (at the beginning, or at the end of the process, for opposite reasons: either for launching the programme or for building it gradually) to very light (for instance, just confined to communication and graphic style). It is in the perspective of a network action that the Museum can play the role of information centre for the whole area, i.e. for the entire set of museums and sites, reserving a space for the presentation of the other knots of the net, or offering catalogs, tickets, etc., for the other cultural components of the network.

### 3.2.2 Demand side oriented actions

Seen from the demand side, a network perspective is more apt to capture the interests and curiosity of a varied public than a single cultural unit. Specific services or programmes addressing a specific segment of the public can be distributed among the different units participating in the network, especially when the organisational capacity of the individual structures is not particularly strong. This means that one unit can specialise in activities addressed to a given segment, but also that it is the whole network, not the single unit, that is capable to meet the interests and needs of that segment of the demand. To give a few examples, educational programmes addressing young children could be concentrated in a single structure or, conversely, every structure participating into a network could contribute, more or less, to the creation of an educational itinerary for children. As already stated, such connections could be permanent or temporary, ordinary or extraordinary.

### 3.3. An integrated perspective

Let us turn now to the integrated perspective, i.e. a perspective involving an interconnected system (a potential tourist district) of elements of tourist attraction, both cultural and non cultural (crafts, agriculture, etc.).

Cultural tourism districts are often proposed as a panacea for local development, but there are precious few examples of success in this field. The reasons are multifold. First of all, in its pure notion, a district is a highly integrated local productive system based on the absolute dominance of a single sector, with all the other sectors sub ordered and coordinated. In that pure form, districts are the result of long historical processes and depend upon a correspondent complex institutional and decision making system. They cannot easily be produced in a limited span of time, and when created, they are often weak from the point of view of their internal integration. This is why, better than a cultural district, a more realistic target for is the establishment of an integrated system of cultural and non cultural tourist attraction, where selected items are connected for specific purposes. This implies, however, a relevant investment both on the planning and on the management side, to the extent that, in general, integrated cultural projects require the creation of a specific agency.

In the following sections, we propose a few examples of possible actions in an integrated perspective, on the supply and on the demand side.

### 3.3.1. Supply side oriented actions

In the integrated perspective, the very notion of cultural (in the broad sense) supply for the area is re-thought. Apart from the single Museum and a possible network of cultural institutions (museums and sites), in fact, it is the entire local area which is read from the perspective of the tourist attraction.

A detailed proposal for the Idlib area will require an in depth investigation, aimed at an accurate inventory of the local resources to be included in the project. At the present state of the art, it was possible however to set out a few basic lines along which an integrated system of supply could be built.

- Agriculture and food represent an important factor of tourist attraction and are easily integrated into a programme of cultural tourism. They contribute to the overall tourist-time budget in a significant way (Syrian cuisine is up to the purpose, but restaurants in the area are much below the minimum standards) and can be the source for appreciated souvenirs to be brought home (sweetmeats, pistachios, olive oil if properly bottled or shipped, etc.). Cultivation techniques, agricultural landscapes, and their artistic and symbolic representation can be a very enthralling experience if well organized (guided tours of visit and tasting promoted or advised in the Museum) and could eventually inspire a pilot project of farm holidays.

- Crafts. Textiles, stone carving, mosaics, wood inlays, olive oil soap, are local products that are often sold in Aleppo or in Damascus without mention of their origin. Protection of such origin by means of trade marks, certificates and logos must be set in place. This is a complex and uncertain process, and must be carefully designed and managed, since it implies a varied series of stakeholders. The Museum bookshop could act, even at an early stage of the process of product protection, as a high quality display of the top products, in ways that contribute to locate them in their own cultural and geographic context, and to manifest the historical continuity of technologies and gestures, of uses and forms. Different units of the cultural network of museums and sites could specialize and focus on different products, depending on their collections or location.

- Events and festivals are common enough instruments to emphasize specific cultural themes and to attract visitors in a selected period of the year, where communities, villages, cities, sites and cultural institutions concentrate their efforts to produce and made available a rare, high quality, multi-layered experience for the visitors. Festivals or events are sometimes tied to tradition, sometimes are recent inventions. In both cases, they require little structural investment (they often take place in existing spaces and areas, and contribute to re-discover and restore them, when abandoned and are mostly immaterial), but a sophisticated planning and coordination capacity and the participation of a variety of stakeholders, from technicians to experts to teachers to local groups or associations (if any).

### 3.3.2 Demand side oriented actions

The integrated approach is the best suited for addressing a varied public, with different interests and attitudes. Each of those interests and attitudes is a potential opportunity to connect the tourist to the area via a specific channel, and if the integration is well constructed, a person in principle only interested in romantic landscapes can be easily induced to appreciate the history or the place, to understand ancient architecture, to taste local food, and so on.

In this context, demand side oriented actions must begin with a detailed identification of the wide range of the possible interests that are connectable to the local supply, and that is possible only once the local cultural (even potential) resources, are fully detected, identified and made at least initially available for use. Basically, the operation is a sort of matrix, where single items of the local system are matched with the correspondent segment (or segments) of the demand. That leads to the creation of different “tourist products” tailored to suit each segment. In this context, a tourist product is a specific organization of the integrated local system, designed to maximize those aspects that meet the needs and the interests of each given type of tourist while minimising the non relevant aspects. It is only after that stage that information/communication strategies become relevant. At that point, appropriate channels can be chosen and appropriate messages can be sent.

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## SCIENCE MUSEUMS BETWEEN SCIENTIFIC RESEARCH, COMMUNICATION AND PUBLIC PARTICIPATION

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### Background

Science museums are very important actors among others –such as schools, higher education institutions, scholars– for developing and improving the public understanding and public participation of science among all the citizens. In the last years, the importance of a strong government commitment toward the dissemination of scientific and technological knowledge among the population, moreover the young population is widely recognised by policy makers, companies and stakeholders, on the basis of the assumption that enhancing knowledge, confidence, participation and awareness about science, would allow having many different benefits. Among them, the growth of knowledge on scientific and technological matters, the attractiveness of the young generation to scientific studies, a new relevance of science for shaping of values, ideas and beliefs within society as a whole.

According to the crucial importance of science education and participation, which affected more or less all the science museums, the definition of aims and missions of such institutions is under debate, in order to address functionalities and role museums are ought to play in contemporary society. The expectations before the museums grew up considerably, and re-thinking about their mission is more and more a central concern for countries. A general agreement is that museums role should be not confined only to educating people, as they are actors able to supply access to scientific knowledge, and recent development on frontiers of research, as well as to sustain the circulation and transmission of the new advancements of science.

Another interesting trend in the European research landscape we faced in recent years is a movement towards the neo-liberal paradigm. It implies: the revision of nature and the role of science as a profit activity, developed with and for the market (changes in justification for public intervention), as well as changes of the relations between government and science. Knowledge is now conceived as a production mean and a good. Control over codified knowledge rise: which is true and valid knowledge? Strong tensions emerged among scientific institutions between historical functions, values, rules, praxis and changes from knowledge production means connected to scientific developments and pressure exerted by policy makers through definite incentives towards the marketing of research and teaching. One of the most important drawback linked to this process is the reduced possibilities of maintaining a strong presidium of basic research for the necessity of favouring “short-breath” research and activities, which give high visibility in short time.

In this context it is important to note that research institutions and scientists might realize economic and societal outcomes through Museums, that are institutions potentially acting at the intermediary level between the science production and the transmission of knowledge within society. The most important advantage for research institutions is to realise a societal impact without upsetting their fundamental mission and being bound in the making of research agenda.

In sum, museums are spaces where people get in contact with “science in action”, as it is when researchers are producing it, and places where scientists and citizens can met and discuss about science and economic and social development, but also instruments for helping public research institutions to circulate and to transmit scientific results, with a valorisation of their impact. How to realize such ambitions is a different problem, and different visions are actually conflicting: do museums enhance their education role, or must they concentrate on communication and participation? What about scientific collections for science communication? Should the science centre model prevail or there is a need for other kinds of organizations? Does the size of the museum really matter?

Our work is not devoted to address these questions directly. Instead, we are interested on exploring how the characteristics of science museums fit with the aforementioned expectations coming from the governments, the business and the society. In other words, we do not intend to analyse advantages linked to a specific profile of museum, but to understand if different typologies of museums exist, and how they address different functionalities and publics.

### Theoretical framework and methodology

Our work takes Italy as a case. We use the results of a recent survey developed by CERIS CNR, in collaboration with Fondazione IBM Italia, on Science Museums in Italy, addressing, through specific indicators, the way in which museums develop research, teaching, communication and participation activities (instruments used and results obtained), the resources they mobilized, scientific collaborations developed at national and international level, the visitors they are able to attract. The survey was carried out in 2007 – it is the third in a series devoted to monitor and to assess functionalities and organisational assets of science museums in Italy. The survey collected evidences on 381 museums, which represents a sample of about 64% of the total.

**Table 1 - SAMPLE UNIVERSE**

<b>SCIENTIFIC MUSEUMS</b>	
– CONTACTED (search for address)	643
– CONTACTED THROUGH QUESTIONNAIRE	594
QUESTIONNAIRES RECEIVED	382
% VALID RESPONSES	100
QUESTIONNAIRES ELABORATED	382

The analysis is devoted to highlight the main strengths and weaknesses of the Italian system, with reference to the new roles and functionalities of the science museums, as well as risks and opportunities linked to the organizational characteristics, and to their openness to international and international collaboration of museums themselves. Moreover, we try to define, using combinations of indicators collected through the survey, typologies of museums according to the activities they effectively develop, and to the outcome they produced. For this purposes we use the approach developed by Laredo and Mustar for public research labs (Laredo, Mustar, 2000).

Studies on science museums (as both public and private organizations) is always evolving. We faced, in the last ten years, a growing differentiation of typologies and fragmentation of the sectors of science museums (Greene, 2001). The aforementioned tendency toward differentiation and fragmentation makes more problematic any tentative of classifying science museums according to the sector addressed. Many attempts to build up a taxonomy as well as to set up a definition which can encompass the variety of functionalities and specialisation of the science museums were carried out, but a stabilized and accepted methodology for typifying science museums has not yet developed. Some authors highlighted that new contemporary experiences of science museums, new types of exposition of scientific collections often derive from the attempt to reduce, at least to some extent, the different speed of scientific and technological innovation, and the capability of society to assimilate the changes proposed by the new developments. These new experiences are not always identified, nor become codified and institutionalised. Nevertheless, science museums are a set of institutions, which need to be unified, with a specific cultural identity and a unique official and shared definition, able to characterise the understanding reality, overcoming the sector differentiations (Pinna, 2004).

This paper tries to deal with the problem of the creation of a typology of science museums, by using a set of indicators able to represent the activity profile of each museum taken into account some relevant dimensions.

A typology is a special case of classification, which is characterised by multidimensionality and by a chosen conceptual framework more than by an empirical base (van Vught et al., 2005). Furthermore, the conceptualisation includes cases that are similar in all the variables or dimensions considered. We adopt the approach of Laredo and Mustar (Laredo and Mustar, 2000) based on a representation of science labs activities through the research compass card model, with some adjustment for science museums. We intend to test the possibility to build up museums typologies based on a characterisation of the institutions by types of activities performed, taken into consideration five main dimensions: education, research, training, restoration and conservation, and communication/participation. In this way, we want to develop a way for analysing the role played by the institutions effectively (what museums, which activities, what the intensity of their commitment, which resources, which localisation and territorial embedding), beyond the use of a formal ex-ante definition of what a museum should be.

In order to build activity profiles of science museums, we look at the involvement of each institution in the different dimensions taken into account, keeping in mind that for each unit (museum) observed, we would find a mix of activities, which will be the factor characterising the museum configuration, or, in other words, the factor highlighting its strategy, willed or not willed, planned or unplanned, deriving from a set of favourable or non-favourable circumstances. The identification of activity profiles allow to compare museums and also to assess their performance, having regard not at groups constituted on the basis of the sector they address, but homogeneous groups because of the activities they perform.

We use the data coming from survey to build museums activity profiles, thus we used mainly nominal qualitative data (presence/absence of activities, their different intensity based on the combination of different variables).

As a second step, the paper also deals with the effectiveness of the different typologies of science museums, with a special reference to those activities aimed at enhancing the social impact of the museum.

## Results

Fig. 1 provide the distribution of Museums in Italy by category: it is evident the prevalence of Natural History museums as well as the importance of Science and Technology museums. More than 30% of Scientific Museums are municipal museums, Universities gather 24,3% of the sample, and Private museums are 21,5%. As to the activities performed, 66,5% are involved in research, 90,1% have teaching activities, and 76,7% develop public participation and communication activities.

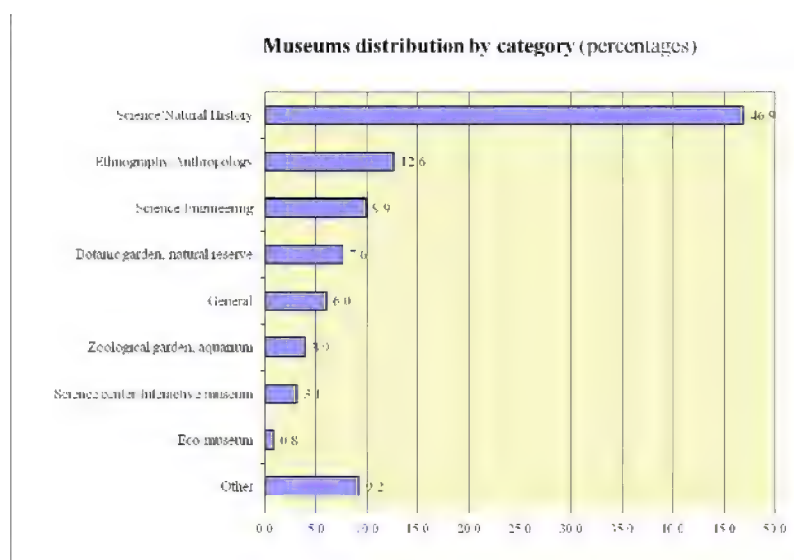


Fig. 1

The situation of science museums in Italy at a glance presents few strong institutions identified through the presence of teaching, research and communication activities carried out with the support of low levels of financial and human resources. This situation generates also a very limited number of visitors in science museums, with respect to the population and the young generation too. Moreover, the size of museum is generally small or very small, the number of permanent personnel is really limited, and the research activities rarely developed at international level. This picture often suggests concentrating on large-sized museums for further implementation of policies, the sole considered able to develop activities with a sufficient effectiveness in terms of social and cultural impact. Moreover, the lack of resources and the small size is supposed to impede the possibility for museums to perform according to the definition provided by UNESCO on what museums should be: "non-profit-making, permanent institutions in the service of society and its development, and open to the public, which acquire, conserve, research, communicate and exhibit, for purposes of study, education and enjoyment, material evidence of people and their environment".

We want to deepen the museums performance, looking at their profiles of activities. We elaborated clusters of museums aimed at designing typologies based on profiles of activities (teaching, research, professional training, conservation and restoration, communication and participation). Each profile includes a set of variables indicating the effectiveness of the activity developed by the museum, beyond the simple declaration of the presence of that activity. Cluster do not include Science centres (4) and museums without a Director (45)

Five typologies emerged, which are characterised by a limited, medium or strong involvement of museums on different functionalities:

- Research Museums (176 out of 218 which declared to develop research)
- Museums specialised in communications and participation (156 out of 255)
- Teaching Museums (187 out of 295)
- Training Museums (143 out of 218)
- Multifunctional museums (56)

Multifunctional museums are characterised by the involvement in all the functionalities (education, research, communication and participation, professional training, conservation) with a light, medium or strong commitment. They have a specific legal belonging (municipality and university), they are concentrated in natural science category (including natural science museums, botanical gardens, aquariums), they have higher rate of human resources than the other museums (35 museums out of 56 have more than 10 units of personnel each), higher visitors numbers, and are mainly localised in North and Centre of Italy (only 6 museums are localised in the South). The size does not strongly characterise this type of museums: although we find large institutions in this group (in terms of personnel), it includes medium ones as well.

These clusters let us make some observations.

First of all we have to recognise that only multifunctional museums are those fitting with the definition of Museums proposed by the UNESCO, since their capability to develop all the functionalities although a different level of commitment (low, medium, high). All the others have to specialize to some extent their action, in order to cope with the availability of resources and to better answer to the external request to the museum.

Second point, strictly related to the previous one, is that research involved a very limited number of museums and its development is associated with the museum commitment to participation and communication activities. Thus,



although the presence of all the functionalities not necessarily can be observed within museums, it is research the one more linked to the development of an impact of museums on society.

Third point is that the effectiveness of activities developed within museums should be carefully assessed in order to understand its value and impact. This implies the need to further develop the work on indicators able to enlighten functionalities within museums and what valorisation really means, pairing quantitative approach with qualitative ones.

Finally, conservation and restoration represent strong commitments for all museums, and they cannot be considered as activities that museums with collections can avoid. The consequence is that the needs to maintain and take care of collections represent for museums with scarce resources a strong constraint for developing other activities toward valorisation; since they are time consuming, need specific competencies and dedicated financial resources. Thus, conservation and restoration are part of the museums mission, and represent a watershed with respect to other organisations, such as science centres, eco-museums, virtual museums, which do not own collections.

How do the different typologies of museums work? Garnett (2002) developed a model of impact of science center, which can be adapted also to museums. He distinguished between the a) *personal impact* of a science center, which is meant like the change induced in a client as a outcome of contact with a science centre (personal enjoyment, career development, changed attitudes to science, science learning, etc); b) the *societal impact*, which is the effect that a science centre has on the people, the urban and natural environment (tourism, employment, infrastructure, leisure activities, etc.), the *political impact*, defined as the influence of a science centre on government, and the *economic impact*, as the direct or indirect effect that a science centre has on local economy (job creation, economic benefits into community, employment creation, etc). Indicators of the museum impact can be identified in the visitors, and in the main users of teaching and communication activities.

Looking at visitors of science museums, we can see that museums in the considered year had a total of 6.619.144, of which 3.124.055 were paying visitors.

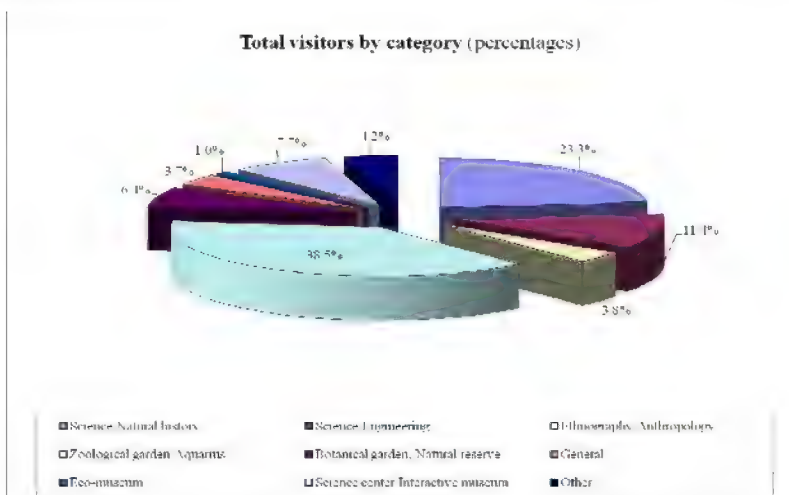


Fig. 2

Using the Gini test we control the level of concentration of visitors between museums: Gini rate has 0 value in case of full equidistribution (all statistical unit have same quantity of considered character) and value 1 in case of maximum concentration. A high concentration emerges, since the Gini coefficient was 0,82. Moreover, 53% of visitors is concentrated in 8 museums: Acquario of Genoa, Bioparco of Roma, Città della Scienza of Naples, Museo Leonardo da Vinci of Milan, Museo di Storia Naturale of Milan, Museo Tridentino di scienze naturali of Trento, Planetario di Roma, Istituto e Museo di storia della scienza of Florence.

Factors influencing the number of visitors are the variety of the communicative and participatory activities, funding and human resources, openness. All the most visited museums are multifunctional museums.

Fig. 3 outlines the main users of teaching activities in science museums and Fig. 4 the groups of users to which the communication and participation activities are directed. This data derived from an assessment made by the museums itself on the relative importance of different users for the activities they develop (we asked them to rank the activities by level of importance, stability and resources invested). As we can see, both activities privilege an audience composed mainly by the very young generations, while less attention is paid to teen-agers and families. Communities from abroad also score very low. Interesting enough, there are no relevant differences between teaching and communication activities: both are more addressed, or less addressed to the same targets of people. This means that museums do not differentiate the aforementioned activities according to their purposes, education in the first case, participation and entertainment in the second. Again, we find that multifunctional museums are those whose teaching, participation and communication activities addressed a large set of users.



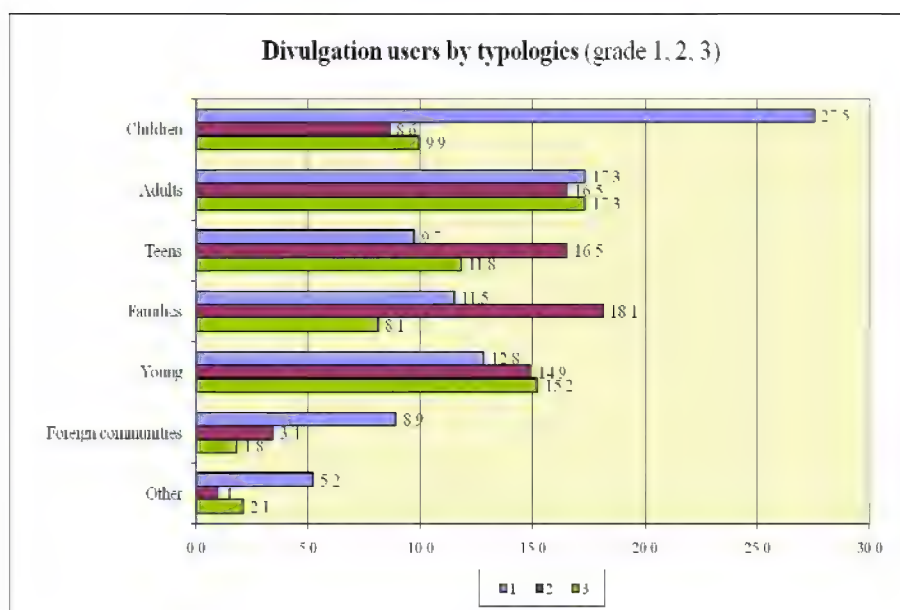


Fig. 3

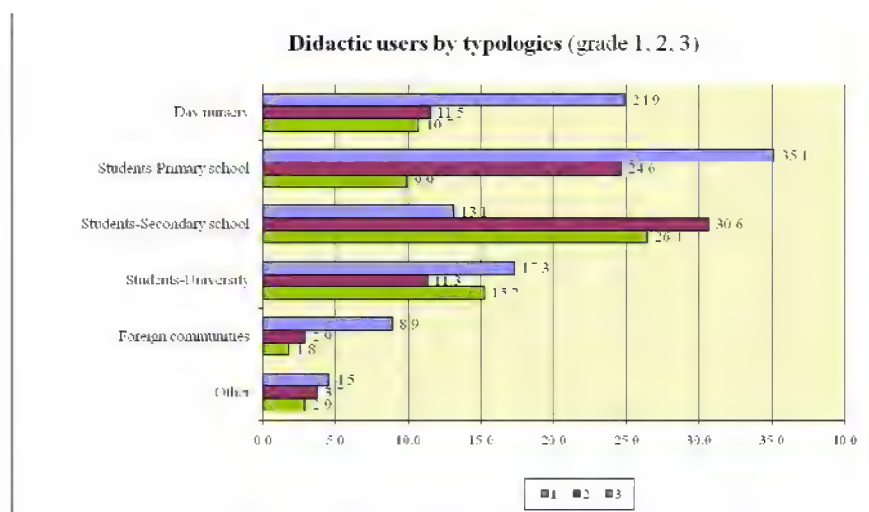


Fig. 4

To this end it is interesting to recall the results that emerged from two different and recently developed surveys. The first was carried out in Italy among a few middle class teachers of environmental education (Caravita *et al.*, 2007), who, when asked which were the most effective methods to teach environmental topics, mentioned laboratory activities in the first place, closely followed by the use of multiple information sources and by visits to museums and exhibitions. Moreover, teachers in the same survey declared that, according to their personal experience, awareness of our relationship with the environment is derived mainly from knowledge acquired from the usual information sources (TV, newspapers and the Internet). The second example refers to the results of a recent survey carried out in Rome and Milan during two meetings on the greenhouse effect and on the water crisis within a CNR project on science communication (Valente, 2006, Id., 2009). Students were asked which sources of scientific information on the environment they used the most. Television, the Internet and school are in a significant position for boys and girls of all schools. Middle school students, however, used a greater variety of tools compared with their high school colleagues: science magazines and specialised magazines, friends and family but especially science museums, which, although not having a key role, which they did not have in the previous surveys either, were identified by a greater number of students in the middle school age group as a more widely-used information source. These data seem to suggest lesser liveliness and curiosity in the search for science information which, in the passage from middle to high school, seems to concentrate on the more traditional sources, neglecting, instead, some of the channels that enable a more direct contact with the work that has been concretely carried out by knowledge producers, in particular specialised magazines and museums. The aforementioned results confirm the declining interest of students of high schools goes together with the less intensive commitment of museums toward this kind of audience.

## Conclusions

There is a general agreement among scholars about the fact that museums role should be not confined only to educating people, but they are actors able to supply access to scientific knowledge, as well as to sustain the circulation and transmission of the new advancements of science. Museums are places where school and society can get in touch with science, discovering it in his making, contextualizing concepts, understanding effects, disputes, ethical implications, wonder of discovering, error values. Museums are also institutions liable of carrying on an intermediary and promoter network role between science and society.

Besides what museums ought to be, the results of our study present a high-differentiated landscape of actors, only theoretically joined toward pursuing the same objectives and goals. Indicators describe institutions whose scientific activities, education, communication and participation are developed with means and methods diversified, and with different levels of effectiveness in terms of visitors and scientific outputs, as well as with different levels of internationalisation.

Indicators show also a great concentration of good performance in all the functionalities in few institutions, and the tendency toward the specialization of others, with many cases of marginalisation of weak actors, due to the lack of resources and public investment. These results do not allow speaking about the role of science museums as a set of activities to be developed by an undifferentiated group. Instead, they suggest the need not to concentrate on what museums should be, but on what they could be, according to their operating conditions. It means not to work for one policy to be applied to science museums, but taking into account their typologies, trying to differentiate policies in order to enhance their potentialities, to take advantages from their capability of collaborating, and to reduce their weaknesses.

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## MUSEUMS FOR THE ENVIRONMENT AND FOR TERRITORIAL AREAS. FROM MUSEUM AS CULTURAL IDENTITY TO MUSEUM AS A DRIVING FORCE FOR SOCIO-ECONOMIC DEVELOPMENT – EXPERIENCES AND RESULTS IN NORTHERN ITALY (1989-2009)

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**Text:** by A. Milan

The end of the first decade of the Third Millennium provides an appropriate moment for reconsidering the far-reaching debate about museum institutions which began and was developed in Italy from the mid-1950s to the end of the century, and to assess its outcome. The experiences were developed on the basis of a long period of theoretical and professional investigation into questions involving the museum environment and its territorial area.

This brief presentation – prepared jointly with Professor Architect Agostino Magnaghi, of Turin Polytechnic – is based on subsequent evaluations of three museums dedicated to the Italian environment and to the local area.

These are the Museo della Montagna (Mountain Museum) at the Fortress at Exilles, the Museo Civico della Laguna Sud (Civic Museum of the Southern Lagoon) in the city of Chioggia and the Museo A come Ambiente ("E for Environment" Museum) in the city of Turin.

The three cases studied, developed and completed over a twenty year period, though different in terms of geographical position and purpose, are similar in their cultural basis and their aims in terms of education and research. In keeping with the guidelines established with the local authorities and regional administrations, these in fact, promote a concept of "cultural territory" which today seems abstract and poorly identified in its essential purposes.

As the title suggests, in Italy, at the end of the 1980s, there was a move away from the cultural approach toward territory, taking the form of a desire for understanding, shared experience and establishing a collective awareness. During that decade there were three theoretical works which condense and focalise the most important aspects of the debate. The main work is certainly "Storia del paesaggio italiano", by Emilio Sereni, published in 1961 but reprinted many times during the course of the 1980s and 1990s. It is the first book to deal with the question of landscape – indeed of "agricultural landscape" – through a Marxist interpretation of territorial area. In the text, the analysis of its structural constituents – agriculture and economy – becomes crucial in comparison with an examination according to parameters involving types of morphology<sup>1</sup>.

During these years, the term "landscape" itself develops new values, reflecting the way in which the modification of "emotional and sensorial perception" is induced by psychological components derived from literature and figurative art. Thus, the Sicilian philosopher Rosario Assunto, in his celebrated essay "Il paesaggio e l'estetica", of 1973, directed the attention of academics to the garden and its significance in Western culture<sup>2</sup>.

But it is the essay, "Territoire comme palimpseste", by André Corboz, published in 1985 in Italy's most important architectural journal<sup>3</sup>, which is destined to have the most long-lasting influence on ideas about territory". Thus the idea was developed – which at that time was entirely original – of metaphorically assuming its significance as "text written on parchment". πάλιν ψήστος (pálin pséstos, literally "rubbed out again", i.e. cancelled out and rewritten over the previous marks and writing. This picture has profoundly interested and inspired generations of architects and urban planners, making the concept of territorial "complexity" more understandable, relating now to a context in which physical elements are defined, in the words of the geographers Lucio Gambi and Francesco Compagna, as "civil" or "voluntary" geography<sup>4</sup>.

In the 1990s the expression "places of value" was gradually developed and identified with a situation that requires individual sensibility, the recognition of belonging to collective values which are in the process of disappearing or are lost. Attached to it was the growing rediscovery – according to criteria which had no shortage of ideological ambiguity – of values of cultural identity connected with regional belonging. A gradual move was to be noted, away from urban centres into open areas, with a dispersion that had a matching correspondence in the idea of the "museo diffuso"<sup>5</sup>.

By the end of the 1990s there was a polarisation of ideas connected to environmental questions. The territorial area was seen increasingly as a "non-renewable resource" whose progressive consumption and deterioration must be placed within a context of "sustainable development".

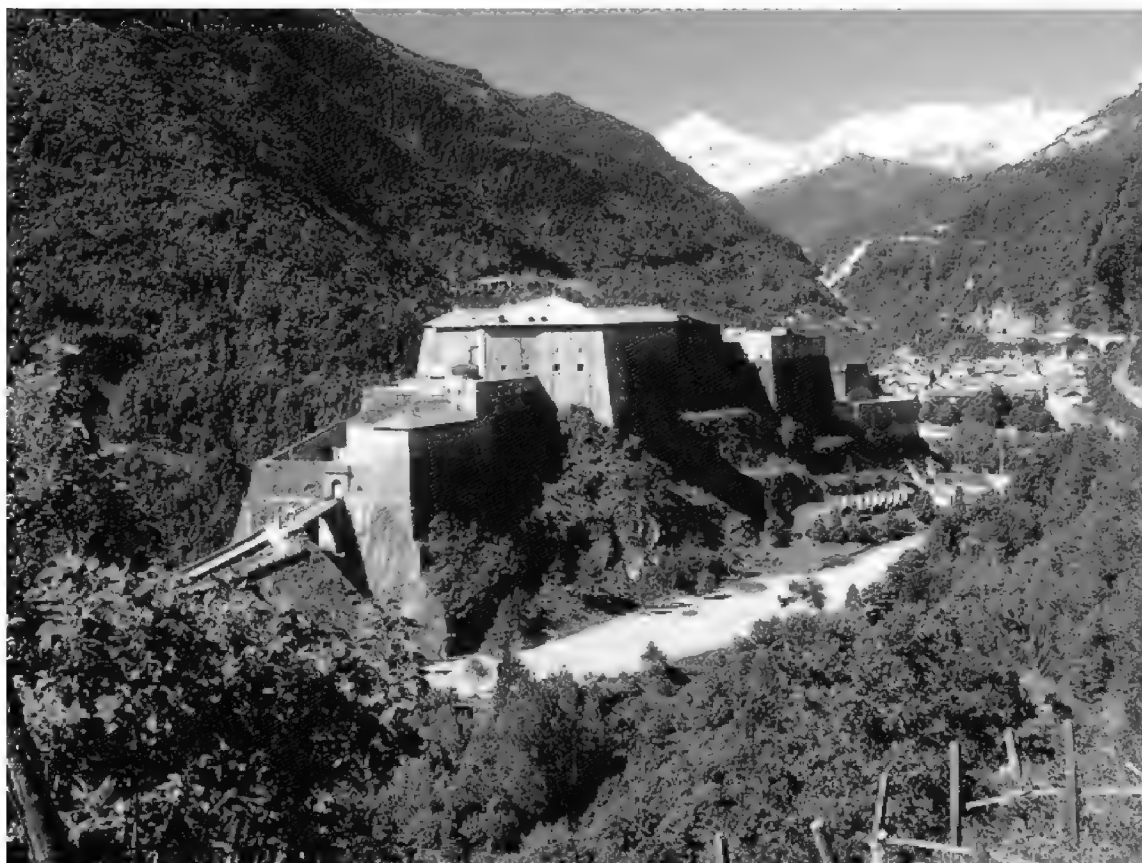
In the radically changed situation of the third Millennium, the museum institution, as a whole, like the university, finds itself in crisis. Compared with a society where the growing weight of economic and financial policies has upset traditional balances, the museum finds itself playing a role of holder and guardian of "values",

distant from concepts of market. It is faced, nevertheless, with the pressing demand to be economically profitable – as a depositary. Such expectation and pressure has ended up eroding its substance and emptying its driving force in social and cultural terms.

The museum has nevertheless been able to present itself as important also from the socio-economic point of view, capable in other words of promoting employment for young people and, subsequently, of generating significant flows of cultural tourism, eco-tourism or sustainable tourism. Such factors have played a significant role, and will hopefully continue to do so, in the Italian economy and throughout the whole Mediterranean area.

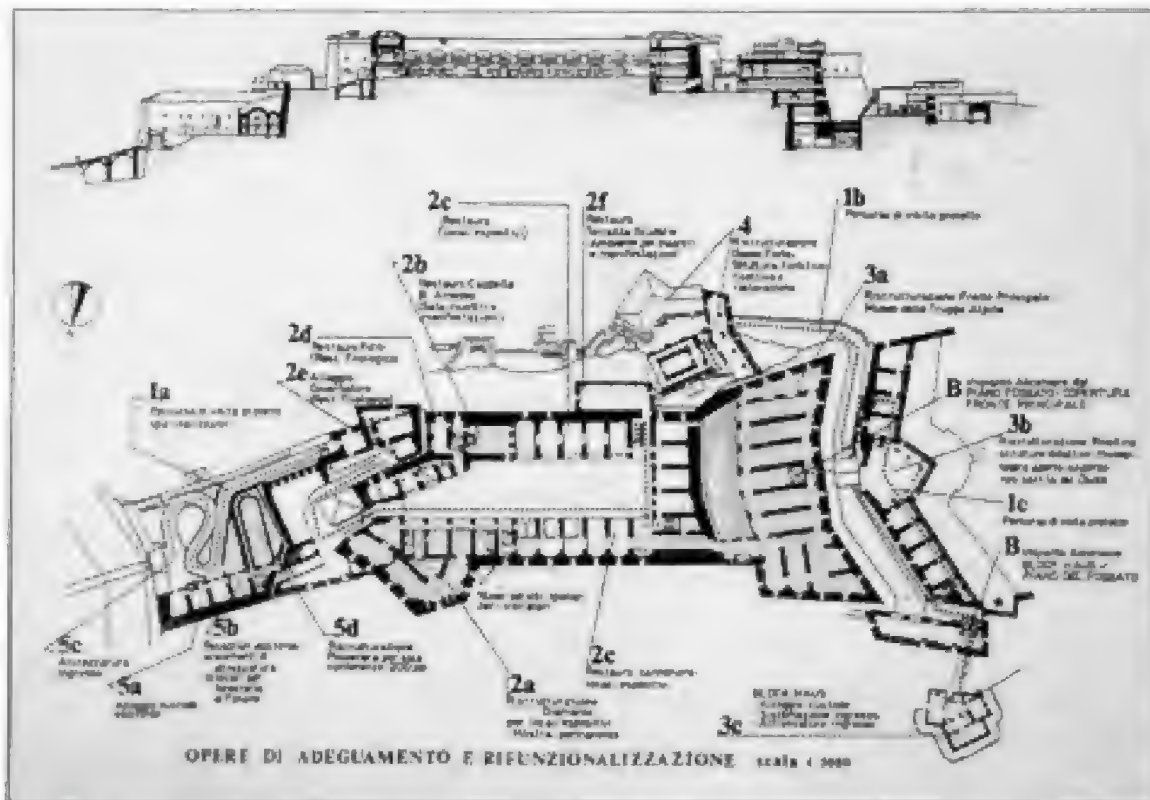
In conclusion, we suggest that it is most important to emphasise the relationship which is established between “museum” and “territory” as a system of complex cultural and physical relationships. Starting from the genius loci and past remains, the tour itineraries both inside and outside the museum “renew and explore urban and historical themes of crucial significance in the Italian city”. In this respect we recall “Tra città e museo”, of 2006, a collection of essays edited by Magnaghi himself, which studies and describes such questions <sup>6</sup>.

Our frequent involvement in these questions – not only in an exclusively professional role as architects – saw us often working as managers and cultural operators, as was implicitly required by the end of the 1980s. The three projects – and their subsequent completion – involved buildings or complexes which had been abandoned, often in a very poor state of preservation, lying outside historical centres (at Chioggia) or in dilapidated industrial areas (in Turin) and, sometimes on sites – though of great beauty – which were logistically inaccessible (Exilles Fort).

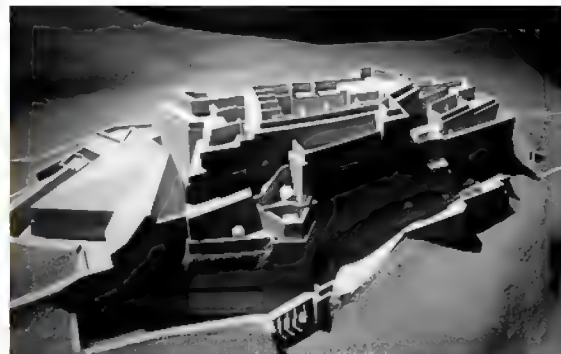


**Fig 1.** - Exilles (Turin, Italy) - The Fort and the village. [Foto: A. Milan]





**Fig 2.** - Exilles (Turin, Italy) - The conservative refurbishment project by Magnaghi-Barrera, 1980. [©: A. Magnaghi – F. Barrera]



**Fig3.** - Exilles (Turin, Italy), The Fort of Exilles – Model of “the Ing. Bertola project”. [Foto: A. Milan]



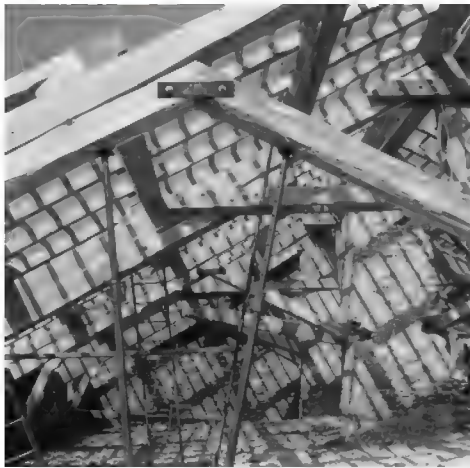
**Fig 4.** - Exilles (Turin, Italy), The Fort of Exilles (National Mountain Museum), entrance bridge. [Foto: A. Milan]



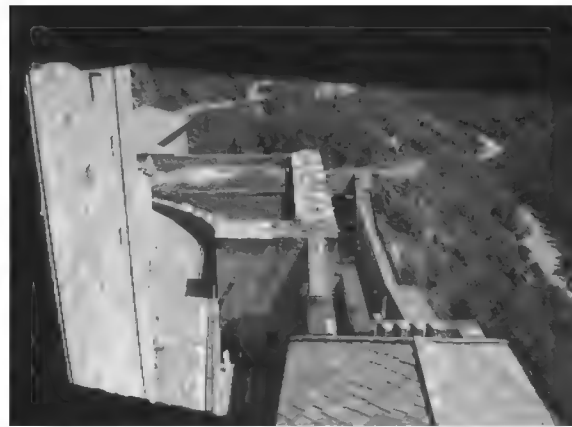
**Fig.5** - The Fort of Exilles, (National Mountain Museum). The second ramp and the well. [Foto: A. Milan]



**Fig.6** - The Fort of Exilles, (National Mountain Museum). The second ramp and the well. [Foto: A. Milan]



**Fig.7** - The Fort of Exilles, (National Mountain Museum). The second ramp and the well. [Foto: A. Magnaghi]



**Fig.8** - The Fort of Exilles. View of the wall walkways towards the river Dora. [Foto: A. Milan]

It has been more difficult to imagine or follow the logical route, the virtual map, of spatial and temporal relationships which the museum would have to construct and render visible, overcoming the neoclassical concept of “museum as container”. In this sense, the arrival of multimedia and digital communication has made it possible to organise and give spectacular impact to learning networks, involving the public in a learning experience which has rich emotional and sensorial value. (e.g.: Museo della Laguna, Chioggia - Museo della Montagna, Exilles).



**Fig.9** - Museum of the Lagoon, Saint Francis outside the walls, Chioggia (Venice) , (Foto: evelyn47)



**Fig.10** - Museum of the Lagoon, Canal Vena, Chioggia (Venice). [Foto: A.Milan, 2009]



**Fig. 11** - Museum of the Lagoon, Saint Francis outside the walls, Chioggia (Venice), [Foto: A.Milan, 2007]



**Fig. 12** - Museum of the Lagoon, Saint Francis outside the walls, Chioggia (Venice,Italy) (Design: A. Maahen-Milan)

Finally, the museum's educational role must be remembered, starting from the youngest age groups, including children of school and pre-school age. The need to combine scientific and cultural rigour with linguistic forms that are expressive, simple and effective (e.g.: Museo A come Ambiente) has led to a dangerous approach of "pure visualism" by the Museum, a temple of aesthetic contemplation, in extolling aspects of learning and communication. Sometimes this occurs to the detriment of the physical structure of the building housing the museum institution.

The following illustrations describe three projects which, it should be emphasised, while created from different political and cultural initiatives and for specific socio-economic situations, have proven to be of great success in the context of the local area concerned and of encouraging interesting results upon the tourism economy.

Exilles is the first of these cases, after almost twenty years of restoration works on the fortress. The military complex originates from the Middle Ages as a "garrison castle" along the road linking Provence and Italy through Monginevro. During its thousand year history it was modified, destroyed and rebuilt several times. Its present layout is the result of reconstruction work carried out in the first half of the nineteenth century. The fortress – disarmed in 1915 and finally abandoned by the Italian army in 1943 – had suffered very serious deterioration over the years during its period of abandonment, almost to the point of ruin. The restoration, promoted by Piedmont regional government, related to the whole layout, from the roofing structures to the living quarters and defences. The project led to the rediscovery of the earlier layouts, using traditional reconstructive procedures and techniques. It has now become the Museo Nazionale della Montagna - Museo delle Divise, focussing on the military events which have affected the Alpine area. A positive economic effect has been felt by the Occitan speaking village of Exilles – a linguistic island – which was already suffering serious depopulation. New flows of tourism have contributed, to an increasing extent, toward improving the economy of this small mountain area. The restoration of the complex has in fact favoured the creation of tourism cooperatives, the launch of craft activities and the promotion of agricultural food products linked to the economy of the Alpine area.



Unlike the case in Piedmont, the creation of the museum in Chioggia – an old fishing centre in the Venice lagoon – originated from the desire to describe and express a strong local identity. The initiative was supported at European level, thanks to substantial funding given to areas in economic decline. The long gestation of the project for the museum – commenced in the early 1990s – coincided with the equally difficult debate on the strategic location of its premises<sup>7</sup>.

The museum is housed inside the Gothic church of the Franciscan convent which had been abandoned after the Napoleonic suppressions and transformed into barracks. It is sited on an island, outside the ancient town, in an area of low-cost housing with considerable social problems. The creation of the museum complex – prior to, and then accompanying, the establishment of the diocesan museum – has strengthened the city's vocation for cultural tourism, helping to support businesses in decline, such as those of the seaside resort.

At the same time, with the use of funds made available by the "Special Law for Venice", numerous works have been commenced for reopening waterways and canals, making it possible also to redevelop the entire housing area as well as monuments and churches. Positive effects – resulting from the opening of the Civic Museum in the southern lagoon – have been apparent since the early years of activity. Twelve years later, the urban restoration work – after Venice, the most ambitious in the entire lagoon area – has demonstrated its value as an economic "driving force". It represents the start of a virtuous business strategy by the local authority which has created the basis for subsequent private investment. Current provisions for tourism in the city – in addition to hotel initiatives – demonstrate the development of an effective ability to interact with the many local resources. The museum, in its administrative role, has also become a centre for campaigns involving archaeological excavations, restoration and recovery of works of art and promotion of traditional activities relating to fishing and shipping works.

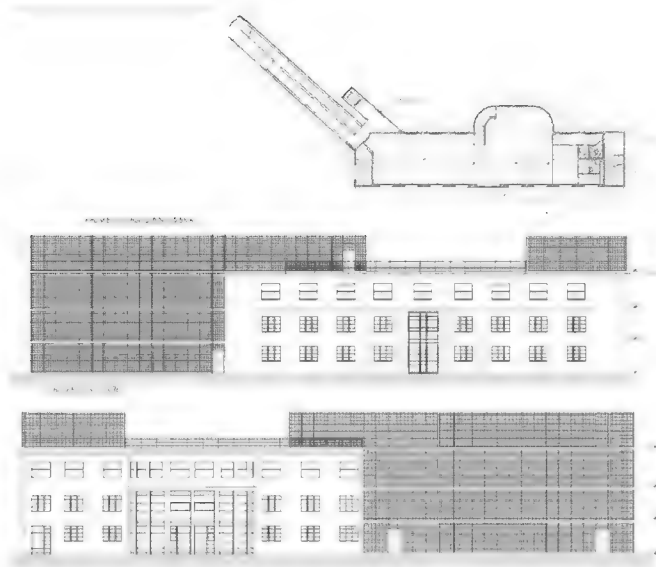
Finally the "A come Ambiente" Museum in Torino is the only museum in Europe dedicated completely to ecology and energy questions involving management and balancing of anthropic systems.

It is housed in the former fire station of the Michelin tyre factory, the only building to survive after the demolition of the factory itself. The operation was co-funded by the City authority using the urban planning charges obtained from building construction works over the area. One third of its management cost is paid from resources derived from the museum activity, while the remaining amounts are provided by the municipal water and refuse disposal companies, as well as by industry, insurance groups and private support.



**Fig. 13** - Ex Fire Station - "ex Michelin" Area, Turin – view before restoration (extension (Design: A. Magnaghi).  
[Foto A. Magnaghi]





**Fig. 14** - "E for Environment" Museum, Turin. The restored building with the new stair extension (Design: A. Magnaghi); [©: Studio A. Magnaghi]



**Fig. 15** - "E for Environment" Museum, Turin. The restored building with the new stair extension (Design: A. Magnaghi) - [Foto: A. Magnaghi, 2009]



**Fig. 17** - "E for Environment" Museum, Turin. The restored building with the new stair extension (Design: A. Magnaghi) - [Foto: M. Pellegrino, 2009]



**Fig. 18** - "E for Environment" Museum, Turin. The restored building with the new stair extension (Design: A. Magnaghi) - [Foto: M. Pellegrino, 2009]

The museum is actively involved in cultural events which are also exported outside the region, as well as in organising fair events and travelling exhibition stands for the purposes of environmental education activities. The museum staff are “external” and it employs technicians and workers who previously worked in the car industry.

It is important to emphasise that, despite the general decline in visitors to museums around the rest of the Italian peninsula<sup>8</sup>, already by 2008 the Turin museum system – which, like Milan, was regarded as a lower tourism attractor – was moving clearly against the trend, with significant increases in numbers. This supports the fact that the new “target” of visitors is the residents themselves, in particular from the younger and school-age groups.

It should be emphasised that this is the third most visited museum in the city of Turin, after the Egyptian Museum and the Museum of Cinema<sup>9</sup>.

The exhibition covers three floors of the museum, while the area on the roof has a permanent educational workshop. By the end of this year a new building will be started in order to extend the museum space. The economic and social effect is measured above all in the promotion of jobs for young people through cooperatives for training environmental guides and educators who are involved in the organisation of events connected with the environment, university science education and industrial economy.

In conclusion:

it seems interesting to consider that the concept, which has been operated for three decades, of matching the museum institution to the building (the so-called “container”), has to be re-examined or superseded. We have ascertained that the operation of local museums is based much upon their ability to effectively communicate and interact, and that such an event does not necessarily need to be carried out from a fixed location but can occur as an “event”, in flexible form, and moveable around the territorial area.

On the other hand, the problem of restoring ancient objects cannot be resolved by local or public authorities autonomously proposing their use in museum (or generally cultural) contexts. As is known among specialists in this area, the sustainability of activities, often at a very high social cost, ought to be evaluated according to their development in time, also and above all according to the costs of maintenance and management. It therefore seems possible and desirable for there to be a gradual reduction in “museumification” initiatives in favour of uses which are as close as possible to those original practices which brought about the creation of the object.

The local museum is mainly a “place in which to spread ideas” which are momentarily brought together within the physical space of that building. If that place becomes a permanent workshop – for research and for developing forms of governing and maintaining the area – the life of the institution (including its economic life) is assured. Otherwise it is condemned to decline and an unrestrainable state of obsolescence.

<sup>1</sup> E. Sereni, *Storia del paesaggio italiano*, Laterza, Bari, 1961.

<sup>2</sup> R. Assunto, *Il paesaggio e l'estetica*, Napoli, Guerini, 1973

<sup>3</sup> A. Corboz, *Territoire comme palimpseste, et autres essays*, Besançon, Imprimeur, 2001 [1983], *it. transl.* : A. Corboz, *Il territorio come palinsesto*, in Casabella, n. 516, 1985.

<sup>4</sup> A. Lanzani, *Immagini del territorio e idee di piano. 1943-1963*, F. Angeli ed. Milano, 1996.

<sup>5</sup> From: *European Landscape Convention - CETS No.: 176*; [it: *Convenzione europea sul Paesaggio*, Firenze, 20.X.2000].

<sup>6</sup> L. Dal Pozzolo, S. Gron, A. Magnaghi, *Tra città e museo. Itinerari, incroci, convergenze*. Prefazione di L. Basso Peressut, Name, Genova, 2006

<sup>7</sup> A. Milan, *Il museo della città e del territorio. Indicazioni progettuali*, in “Chiossola,” n.10, dic. 1993, Veneta ed. Conselve (PD), 1993.

<sup>8</sup> *Dossier Musei 2009*, Touring Club Italiano, Milan, 2009.

<sup>9</sup> Three years after its opening, it has an average of forty two thousand visitors a year, generally aged between six and twenty five years. Forty eight per cent of visitors are in fact primary school children, twenty six per cent from junior schools and the remaining twenty two per cent from secondary schools and universities.

# MAREA – AN ARCHAEOLOGICAL STUDY AND THE MANNER OF ITS TOURIST INVESTMENT

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**Keywords:** Marea, Secular Archaeology, Tourism, Environs of Alexandria

## 1. INTRODUCTION:

In each tourist country an element always comes out among other factors which draw attention for the tourist importance of this country; Greece with its islands, Lebanon with its mountains, Italy with its monuments and France with its funfairs are considered amongst the most remarkable factors for tourist attraction in these countries. In Egypt, where international conventions are interpreted from the perspective of antiquity; Thus amongst the main assets in the tourism industry in the country, stands the Egyptian archaeological and historical heritage, the most prominent.

Thereon, tourism is livelier in Cairo and Luxor all year round than elsewhere in the country. That is due to their being located nearby important antiquities. So for example, without the pyramids of Giza and the antiquities of Saqqara being in the neighborhood of Cairo, the tourism business in the Egyptian capital might have differed.

With this in mind, and with the knowledge that the monuments of Alexandria, till present, do not possess the same power and do not play a fundamental role for winning the tourists over to the city. Thus it became incentive to create a tourist district neighboring to Alexandria being plentiful of its antiquities that offer novel for the tourist. In this respect it would activate the field of tourism business in this deeply rooted city. Therefore, I found it worthy through this paper to throw light on a neighboring town, only 45kms southwest of Alexandria that is exuberant of its antiquities; namely Marea [Fig:1].<sup>1</sup>



**Fig: 1 Marea and Environs**  
(after, Karl Petruso, Creighton Gabel (1983) *Archaeology* Sept./Oct., p. 63)

Marea is a name of a town that widely frequents in the writings of the classical sources since the late Pharaonic till the early Byzantine Periods. Its name was chanted by Classical Poets in their praises of the growing of grapes and the production of wine in the town.<sup>2</sup> Marea is a name of a town by the first moment of its discovery in the late 70s, it gained a wide scientific and media propaganda that proved beyond doubt that the site is of exceptional archaeological interest. It is a subject that raises many problems for researchers and scientists: Was Marea as believed by El Falaki<sup>3</sup>, Kees<sup>4</sup>, De-Cosson<sup>5</sup> and Fraser<sup>6</sup> was one city that lived all periods of Egyptian civilization; since at least the late Pharaonic period till the Byzantine and early Islamic epochs; or was Marea as Botti once wrote a name of two towns, the ancient and the new?<sup>7</sup> or was there more than one town that lived with proximate names in different epochs?; Is the now known location of Marea that was defined by El Falaki in 1850 relying on the map of Ptolemy the geographer, and was copied by De Cosson and accepted by The Survey Department of Egypt as the location of the ancient town; Is this location conformed to the real place of Marea or was it as Gauthier previously deducted relying on his study on hieroglyphic texts and inscriptions that the ancient town of Marea, the capital of the

Mareotic province was on an island in the lake<sup>8</sup> or was it else where as contested by some scholars such as Daressy<sup>9</sup>, Montet<sup>10</sup> and recently Rodziewicz. Finally, Was the town's name as lately provoked Marea or Philoxnité?<sup>11</sup>

## 2. THE CITY'S DISCOVERY:

Apart from the visible jetties of its ancient ports, which are still projecting into the lake on the site, Marea's secrets remained covered by the sands of time until the 1st archaeological survey and excavation in search for the town took place in 1977 by the University of Alexandria under the direction of Prof. Dr. Fawzi El-Fakharani.<sup>12</sup> This excavation revealed the answers of a great deal of the aforementioned inquiries, the most important of which is that it assured that Marea was a name given to two neighboring towns on the southern coast of the Lake. The 1st, which was Pharaonic/ Ptolemaic and Roman, was on an island in the lake close to the coast., while the other which was wrongly thought to incorporate the two towns of Marea, was Byzantine, located 5km to the east of the former one, and was established at least two centuries after the death of Ptolemy the geographer.

The earlier town of Marea was that one called *Palaemaria* on Ptolemy's map, and which was translated by J. Ball as the "old village of Marea".<sup>13</sup> This explains the decadent position of Marea to a village in the Roman period as reported by Athenaeus.<sup>14</sup>

The latter town of Marea replaced the earlier one after its deterioration in the Roman epoch. This town was developed as a port on the lake southern coast owing to the fame of the shrine of St. Menas the martyr, whose miracles attracted throngs of pilgrims and patients from all over the Christian world seeking health achieved by his miraculous holy water only 15km to the southwest of Byzantine Marea.

Since its discovery in the late 70s, works of restorations and diggings in the Byzantine site sequenced till present through the EAO and numerous archaeological missions, which are still unearthing many of the town's secrets.

Since it is possible to see in the ruins of Marea a number of encouraging features, Therefore I found it is worthy to show the importance of Marea through a detailed survey of its antiquities in particular those which are susceptible to extinction.

## 3. THE ANCIENT PHARAONIC / PTOLEMAIC CITY:

The remains of the ancient Pharaonic Ptolemaic city of Marea were discovered either on the island or dug in the rock on the ridge to the island's southwest. Those at the north coast of the island show a Pharaonic port, shaped like the hieroglyphic *Pr-sign*; a shape that sufficiently enables safe anchorage for the vessels, being sheltered from winds, waves and water currents [Fig:2,3]. This port recalls the shape of the Pharaonic ports on the Mediterranean, such as the natural submerged harbour discovered by F. Godio in the East Port of Alexandria in 1996.

Further to the east of the pharaonic pr-shaped port there was found a single quay jutting out into the lake marking the Ptolemaic port of the town. However further in land to the west of the pharaonic pr-shaped port lie the ruins of the fortress of Psammetic In its design it mightily corresponds with the reconstruction of the fortress of Daphnae built by the same king to guard the eastern border of Egypt.<sup>15</sup> It also recalls the plan of the fortress of Semna built by Sesostriis III to guard the southern border of Egypt.

On the ridge to the southwest of the island were discovered The Graveyard of the town as well as the two Ptolemaic cisterns. The late Saitic Pharaonic Cemetery has 26 burials each with its false door. The cemetery is also characterized by its ceiling that was carved in imitation of wooden logs recalling the step pyramid funerary complex.

On the same ridge very close to the late dynastic cemetery, there were found a variety of burials mostly dated to the early Ptolemaic period, and last in use afterwards. This Ptolemaic cemetery consists of: loculus tombs, pit tombs and chamber tombs [Fig:4].

## 4. THE BYZANTINE CITY:

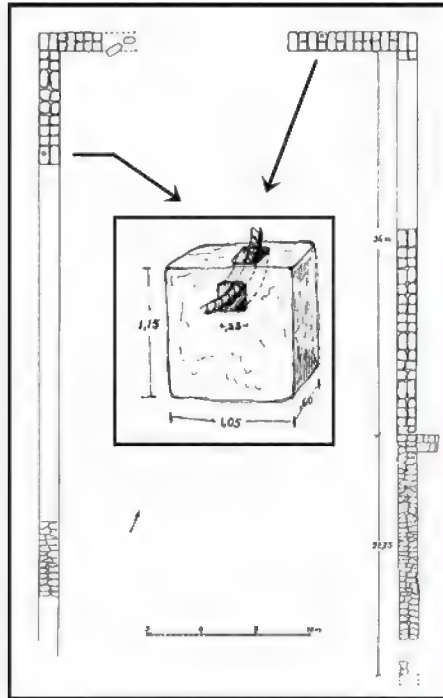
As for the Byzantine city of Marea, On the basis of the extent ruins discovered in numerous parts of the town, on the lakefront and several kilometers to the south, thus the study induced to institute a systematic method in order to facilitate archaeological reconnaissance and mapping of the site. Therefore, a division of the town into three regions breadthways was proposed, namely: The Coastal Region, The Central Region and The Southern Region

### 4.1. THE COASTAL REGION:

The Coastal Region of the town, which comprises the harbour with its three major ports: The West, The Middle and The East Ports, as well as the excavated buildings around the harbour and along the lakefront. Archaeologically, this harbour is the major and sole information about the local lake ports. Unlike other Mediterranean ports, this is the only one which neither subsided beneath the sea nor been built over by later inhabitants. Each of The West and The Middle Ports resembles a half open basin formed of two quays enclosing part of the lake southern coast [Fig:5].



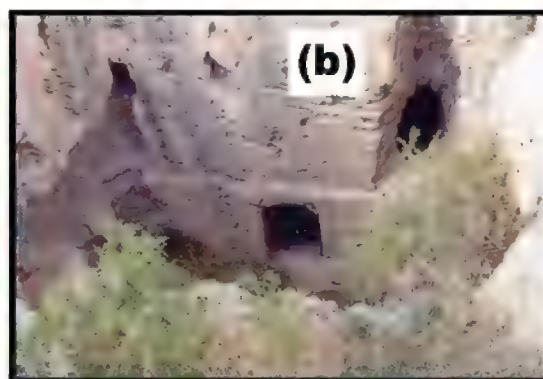
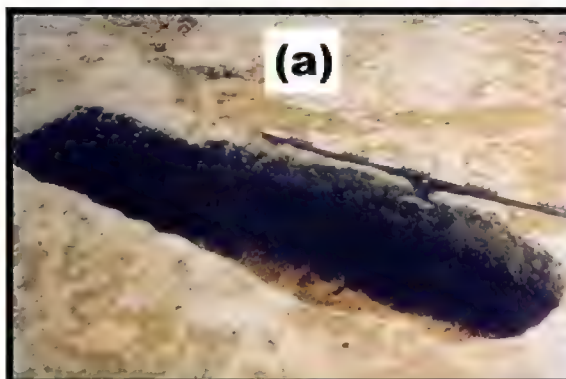
The East Port is of a special nature, it was built on sporadic islands in the lake to the east of a land promontory separating it from the middle port. In its first stage it resembled the other two ports, later it was enlarged by constructing a new quay extending from north to south parallel to the promontory and stops about 30m far from a small island to the south forming a southern exit of the port.



**Fig:2 Plan of the Pr-shaped Port**  
Inset shows block's cavity for ship hawsers  
(after the unpublished PhD dissertation: Nashwa Soliman(2004)  
*Marea – An Archaeological Study and the Manner of Its Tourist Investment*, Alexandria, figs 11, 12)



**Fig:3 The Pr-shaped Port of Pharaonic/Ptolemaic Marea**  
One of the blocks with the cavity for ships' hawsers



**Fig:4 Parts of the Ptolemaic Cemetery**  
(a) An anthropoid pit tomb (b) A square shaft of a chamber-tomb

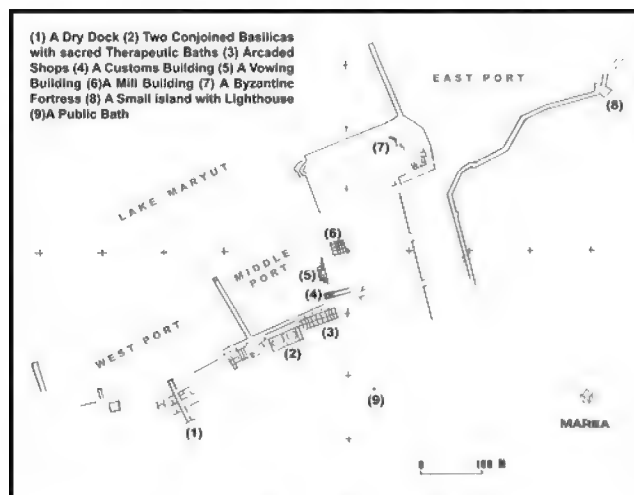


Fig:5 The Harbour of Byzantine Marea  
[after Nashwa Solieman (2004) op.cit, fig.24]

A variety of suggestions concerning the port's function were held by scholars and have been argued through the study. Yet a new function was attributed to the East Port through the quay atop the promontory that was skipped by all scholars. It is of a later date than the other quays of the harbour. It is the widest, the longest, and the most protruding among them into the depth of the lake. It is also constructed close to the remains of a structure most likely belong to a Byzantine fortress. In other words, the target of this quay might tend to provide adequate working space that would be convenient for a Naval Military Outpost. Recent investigation of the northern island of the port revealed references of metallurgical activities, which tend to support this supposition.<sup>16</sup> Thus, the modification of the East Port was meant to facilitate escort's navigational traffic between this quay and the Nile [Fig: 6, 7].

In the west Port a Byzantine dry-dock partially extending in the lake water was unearthed in 1981. It consists of a central aisle with two parallel runners extending into the lake. The gradient is quiet gentle compared to other ancient slipways in the Mediterranean, and would have permitted a team of men to haul a ship up the slipway using ropes and log rollers [Fig: 8].<sup>17</sup>

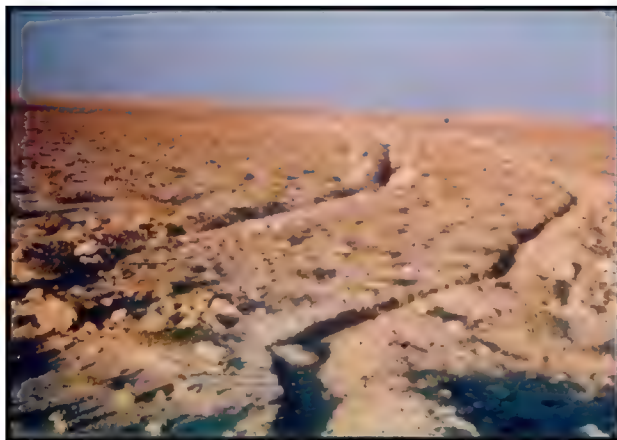
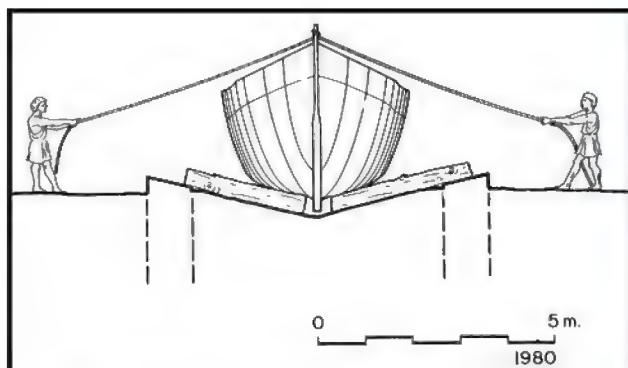


Fig:6 The Sunken Quays of the East Port  
showing the changing in direction



Fig:7 The East Port  
Suggestion of Traffic Navigation



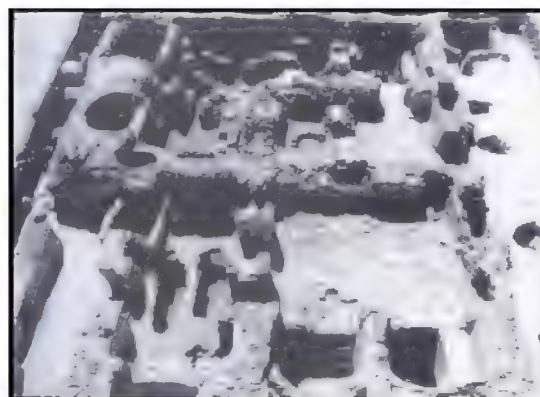
**Fig: 8 Proposed reconstruction of the Dry Dock**  
(after, Karl Petruso, Creighton Gabel (1982) *WP 62*, fig.5)



**Fig:9 Stair-base at the rear of some shops**



**Fig: 10 The Mill Building - the room with the mill stones**



**Fig: 11 View of the Public Thermal Bath from the North**  
(after, Szymańska H., Babraj K. (2002) *PAM III*, fig 4)

The southeastern corner of the middle port preserves the remains of a very unique structure of no counterpart among the antiquities of the ancient world. Apart from the field reports, this building was not studied before. It was built completely in the water of the port. A wide variety of artifacts was uncovered in its water canals, nearly intact. The study of these artifacts interpreted the structure as a vowing building for receiving votive offerings consecrated to the most favorite patron saints in Egypt; namely St. Mark, St. Menas, St. George with reference to St. Theckla, where ex-votos by being thrown in the water would achieve its association with the holiness of these saints.

Along the Waterfront, where there were discovered the decumanus running along the coast from east to west, and a well-constructed shopping arcade with living quarters for the merchants in their rear or on an upper storey as deduced from the stair bases unearthed in some shops [Fig:9].

Shop no.8 is the sole pattern in the shopping arcade, where the architecture of its domicile became almost complete after the recently unearthed units at its rear interpreted through the study as latrines owing to its elements that were common in antiquity. The podia pierced with the holes represent the seats over the sewer channel, carrying away wastes that would be drained through the drainage chamber behind. Shop no.9 has been interpreted through the study as a glass workshop as deduced through the dense scatter of slag noticeable at its entry and the existence of a round furnace in its front hall of the type used in glassmaking industry.



To the west of the shopping arcade there was discovered A Pair of Conjoined Basilicas. Later in the Byzantine period modified to coincide with the nature of the town as a port and a resting place for throngs of pilgrims to the holy shrine of St.Menas, by incorporating therapeutic baths similar to those of St. Menas, a dormitory in the upper storey, a shop selling miracle-working water of the Saint, a refectory or restaurant for serving food, cooked over the now demolished stove, for hostellers, pilgrims and others in addition to the main function as a place for worship.

Still at the waterfront there were revealed a multi-roomed building on the promontory that served in its latest phase as a grain mill, where there were discovered two large rose granite millstones.<sup>18</sup> There were also discovered a large rectangular water cistern, a circular base of an oil press with its apparent nozzle, a furnace, which is now vanished, a solid circular platform interpreted as a kneading board. All these features pointed to an active bakery [Fig:10].

Very recently the polish mission under the auspices of Warsaw University unearthed a public Thermal Bath to the southeast of the shopping arcade. The bath complex is composed of two units for men and women with opposite entrances. Being heated by the hypocaust system, where hot air was directed under the floor and via hollow tiles in the walls [Fig:11]. Further to the east references of a chamber tomb came to light, marking the eastern outskirts of Byzantine Marea.<sup>19</sup>

## 4.2. THE CENTRAL REGION:

In the Central Region of the town, the structures discovered demand its division into a living quarter and an industrial quarter.

### 4.2.1. THE LIVING QUARTER:

The housing establishments in the living quarter varied from the wealthy villa rustica to common public dwellings. There were uncovered a remarkable large house of a Christian noble. It consists of two peristyles with a small church separating them. This building was later transformed into a hospice for pilgrims journeying to St. Menas shrine. The building shows unique characteristics, about which scholars differed in their opinion. Although some of its features are now vanished, but through a comprehensive scrutiny aided by original plans and photos taken at the time of their discovery, the study came upon their interpretations; like the kitchen's stove and bakehouse tunnel that were wrongly interpreted as a second latrine, the grain millstone and the built-in stone funnels of the lavabo that were wrongly interpreted as remaining of a winepress [Fig: 12].

As for the public dwellings, they were recently unearthed to the west of the peristyle building in the form of an *insula* containing various tenements and shops, defined by a network of straight narrow streets intersecting at right angles [Fig:13].

Amid the distance between the double peristyle building and the aforementioned public dwellings, the Supreme Council of Archaeology unearthed a great part of a public *thermae*, the architectural elements of which were identified in the course of this study: the *apodyterium*, the *frigidarium*, the *tepidarium*, the *caldarium*, the *laconicum*, the hypocaust vaulted cellar and the main water supply cistern.<sup>20</sup>

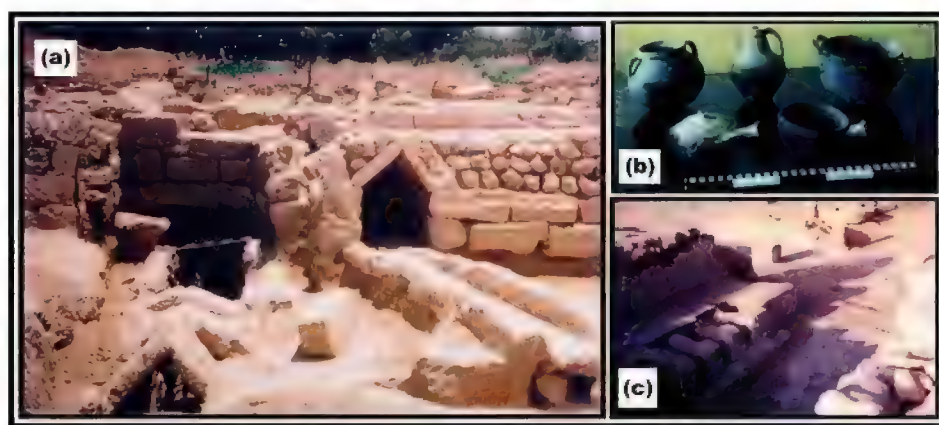


Fig: 12 Remains of the Kitchen of the Double Peristyle House  
(a) The bakehouse tunnel (b) Some of the pottery vessels unearthed from the tunnel (c) The Podium over the tunnel working as the kitchen's stove (after Nashwa Solieman (2004), op.cit, plates:90, 93,95)



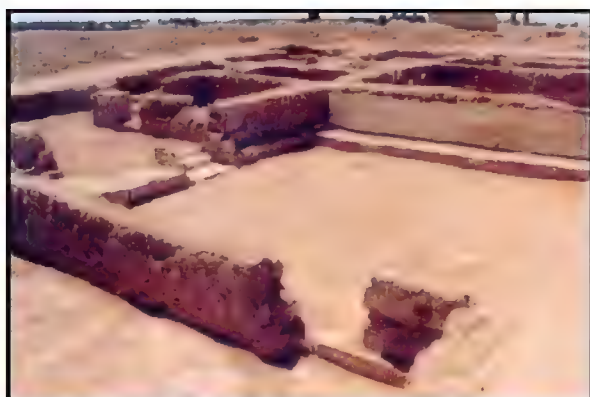


Fig:13 The Public dwellings -The second commercial unit  
(after, Nashwa Solieman (2004), op.cit, pl. 111)

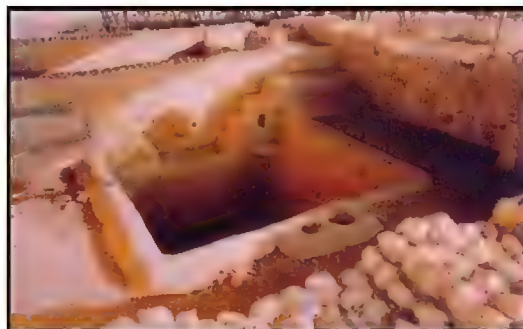


Fig:14 The Big Winery of Marea  
General view after the works of restorations



Fig:15 Imaginary Drawing illustrating the activity in the Big Winery  
(after, Wingert-Uhde, H. (1978) Stern Magazin Nr. 23, 1-7 Juni, p. 11/B)

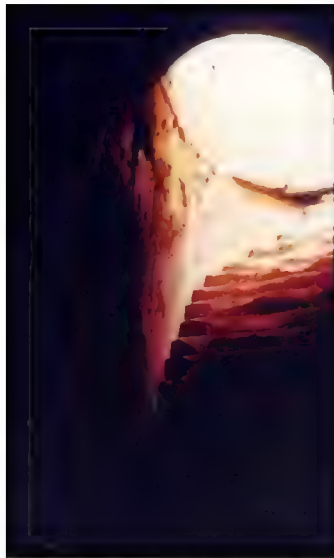
#### 4.2.2. THE INDUSTRIAL QUARTER:

Further inland in the industrial quarter of the town is defined by the two wineries discovered, supplying striking confirmation of the vital role held by wine production in the economy of Marea. The two wineries are almost identical in their basic elements, while the big one seems more developed and complete than the small one. The different operations needed for winemaking is fully represented in both wineries of Byzantine Marea, namely; *The Crushing, Pressing & Squeezing, Filtration & Clarification, Blending the Juices & flavorings, and finally Fermentation & Aging* [Fig: 14, 15].

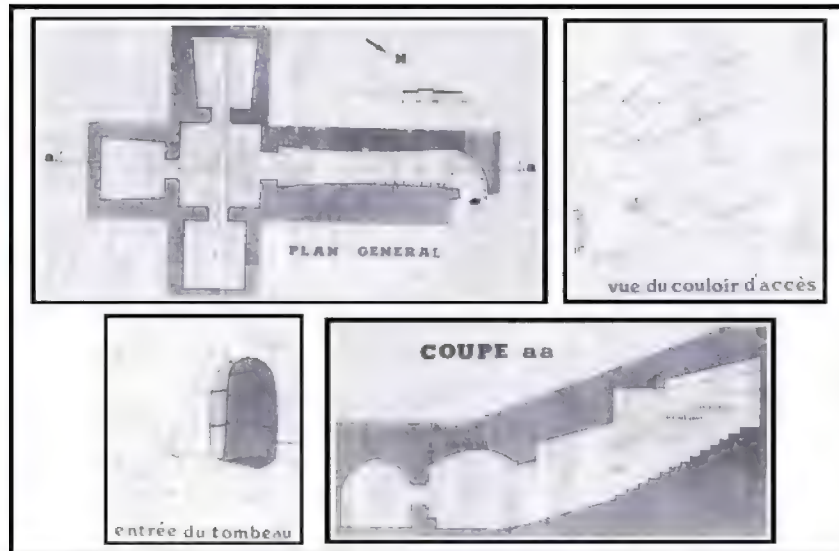
The study of water sources of the town in antiquity denotes the use of wells and cisterns in addition to the Canopic Nile feeding the lake being the main source of freshwater.

#### 4.3. THE SOUTHERN REGION:

In the Southern Region of the town the cemetery exists as represented through the cruciform chamber tomb with its recently discovered funerary chapel. It is *characterized by its architectural features specially the use of a wide variety of vaults*. This tomb marks the southern outskirts of Byzantine Marea [Fig: 16, 17].



**Fig:16 The Byzantine Tomb**  
The entrance of the tomb as looking from inside



**Fig:17 Extracts from the Plan of the Byzantine tomb surveyed and drawn by Eng. Neel in 1979**  
(after, Nashwa Solieman (2004), op.cit fig:67 "Tombeau byzantin enterré")

## 5. CONCLUSION:

Marea, if we meditate deeply on this city we will find that it has:

- All such historical expansion
- All such variation in its establishments, in terms of all aspects & times
- All such intermixing of consecutive civilizations
- & All such development and variation in beliefs and ideologies

Such variation makes us see clearly how different classes of common people lived. This is not limited to the ruling class as in most other archaeological sites in Egypt, where the majority was related to temples, tombs and royal buildings.

Italy, as a tourist country, boasts over its cities, Pompeii and Herculaneum, and Greece is proud of Delos because they represent the life of their people at the end of the Hellenistic era and the beginning of the Roman era in a period extending almost two hundred – year – time.

Thence, how could the archaeological sites in Marea be valued whereas they reflect the daily life of the Egyptians as well as their burial places? It is considered an alive museum of Egyptian civilizations and a unique among all archaeological sites discovered of the ancient world as it depicts the civilizations, which lived on the Egyptian soil for a period not less than 1500 years. Still the city is considered as an open exploration field promising for numerous scientific bodies. What cultural value would be compared to this?!

The historical value and the scientific position of Marea urging to revive its glory brushing away time dust and prepare it to welcome its guests from all over the world. In this respect, the tourist Evaluation of Marea demanded a General Visualization of an Integrated Tourist Project for the town that was proposed through the study.

The priority of developing the monumental Marea city should be set before all governmental and international domains, specially that these unique antiquities if not being preserved by the suitable scientific method, would be subject to extinction and the loss , while the main task of the monument is to continue to act as a witness to its period for future generations.

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# CULTURAL TOURISM AND ECONOMIC DEVELOPMENT IN THE URBAN CONTEXT OF ALEXANDRIA

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**Keywords:** Cultural tourism; Economic development, Alexandria

## 1. INTRODUCTION

This paper deals with cultural tourism in conjunction with economic development highlighting positive and negative factors linked to tourism itself. Then it proceeds to examine the structure of tourist supply and the analysis and planning methodologies.

The central theme is the tourism in the Mediterranean and, in particular, in Egypt, a country that is very dynamic and offers a complex situation which is evolving rapidly. Cultural tourism is a traditional and important dimension in the tourist sector in the country. Interesting are the plans of development of the tourism sector and the role of the General Authority for Development of Tourism.

Specific attention is given to the city of Alexandria, rich of institutions and cultural activities, and therefore it is seen as a potential cultural district.

## 2. CULTURAL TOURISM

Cultural tourism is growing in importance at national and international levels. It is a multidimensional phenomenon and it is important for relationship between countries. Currently the cultural tourism is an important instrument of knowledge; an integration accelerator and a vehicle of culture<sup>1</sup>, as well as factor of economic development.

Traditional societies are involved and affected by the impact of tourism; residents will know the positive effects, as well as negative ones [1]. You may lose the cultural significance of local traditions, a standard tradition is "reinvented" for purposes related only to economic and tourist to satisfy the standardized desires of mass tourism. We must resist this standardized culture, maintaining the cultural differences.

Tourists go elsewhere for purposes of knowledge (cultural tourists) and use of time leisure<sup>2</sup> tourism can be linked to other travel purposes such as business, etc. The tourist has behaviors mixed with regard, for example, the duration of the stay and the choice of the place of residence<sup>3</sup>. Cultural tourists can be attracted by a single cultural asset, or by specific place, linked to certain aspects of local culture. These places attract tourists mainly when there is a significant cultural heritage.

Neighboring towns can be affected by the dominance of a place, or even a monument. A different situation occurs if the centre of cultural interest also integrated surrounding areas thought a coordinated and integrated action to improve and enrich the supply. Tourist routes or networks of cultural goods in a broader territorial perspective providing marketing and management cost reduction can be activated.

Tourism has positive consequences for economic development [5]. Therefore, it supports the tourist industry, trade and crafts; produces revenue, profitability, wealth and new jobs. If tourism in developing countries shows negative aspects, it may increase crimes, social conflicts, overcrowding, destruction of the environment, dependence on multinational companies and, in general, on industrialized countries. Income, on the contrary, must be distributed in large part on the territory and not retained by the large operators.

Over time, tourism took a commercial feature becoming a mass phenomenon: the tourist offer is handled mostly by international operators [4]. These forms of tourism offers sparsely cultural aspects even if cultural tourism, as a form of knowledge and information transmission, represents an important level of tourism itself, which grows thanks to the development of the communication technologies.

Tourism must be organized and managed as a corporation. In the cultural tourism marketing is relevant the possibility of access to the place of supply in order to be able to increase the number of visitors and enhance cultural goods. On the availability is involved local information communication<sup>4</sup> through media<sup>5</sup>, hotels receptive services are strategic, as well as all receptive service and restaurants: Very important is the availability of transport infrastructure: roads, airports, railways, etc.

Tourism has increased due to the growth of motor vehicle for the development of transport, aircraft, including low cost, and the same self-booking journeys that promote travel and tourism. The changes in the labor market such as the week of five working days, paid holidays, are other relevant issues.

Globalization itself concerns issues of competitiveness between regions, however, maintaining the need for sustainable development [9]; the concept of sustainable development involves respect for cultural and environmental goods that are likely to be damaged or run out.

Tourism can be investigated using the cost-effectiveness analysis and related methodologies such as the SWOT analysis. It is, however, necessary to alleviate the adverse consequences considering environmental and social costs



compared to the economic benefits. We need to use the planning techniques, giving priority to residents needs; tourism must be a territorial resource to discover places and culture through the planning and the improvement of market policies and the vocational training of employees in the sector.

It is important to analyze the type and the number of tourists, the level of regulation of the sector, tourism businesses, tourist programs, public and private initiatives, national, regional and local operators involved.

### 3. TOURISM AND MEDITERRANEAN

In the Mediterranean the economic development can be driven by the tourist sector, taking into account the large existing cultural heritage. This cultural heritage in the Mediterranean is diversified; it comes from a history, specifically from the first Asian civilization and presents tangible items such as landscapes, monuments, historical centers of cities, cultural production and intangible assets as civilization, traditions, culture, society [7].

The 1995 Barcelona Conference has stressed that the Mediterranean must become a heritage only highlighting significant cultural and environmental goods and celebrating, however, cultural differences.

Integration concerns the cultural heritage, retraining policies and tourism market to promote economic development, maintain cultural identity, to grow the business, retrieve traditional activities [4]. Tourism can contribute to the protection and enhancement of the territories and local resources, promotes cities redevelopment and safeguard local production and crafts <sup>6</sup>.

It is important to use strategic planning precisely for the countries of the Mediterranean, alongside related techniques in a manner specific to tourism. The strategic planning applied to the tourism sector wants to preserve, enhance, and retrieve the local cultural heritage.

### 4. TOURISM AND ECONOMIC GROWTH IN EGYPT

#### 4.1 TOURISM CONTRIBUTION TO DEVELOPMENT

In Egypt, tourism scenario is complex. The coast of the Red Sea and the Sinai Peninsula are transformed into areas of foreigners without any contact with the local culture and the territory that is, on the contrary, corrupted by the excessive market size, and by the lack of respect of the place by mass tourism.

In the analysis of a territory, in this specific example Egypt, it is important to examine the resources related to cultural tourism, tourist trends and tourism as a resource in order to retrain places and activities. Not is, however, easy to distinguish sustainable tourism supply by integrated cultural supply or other kind of tourism supply.

In Egypt, the tourism model is driven by the supply which has mainly characteristics of mass tourism and is not very expensive; tourism is managed by international agencies, hotel chains and airlines. As a result, there is an international model of tourist, the typical western tourist, particularly in some areas.

Tourism account for 11,3 % of Egyptian GDP and 19.3 % of revenue from foreign currency [2]; according to the Egyptian Central Bank the tourist sector earned in 2007 9.4 billion of dollars<sup>7</sup>.

Tourism absorbs a large proportion of labor force creating workforce of more than 2 million: with 1.147.000 people working in hotels. Private investment in the tourism sector is growing.

According to the World Tourism Organization, WTO, the 2007 tourism is growing rapidly with a number of tourists reached approximately 11,1 millions of visitors. Tourist companies were approximately 1.409 in 2007.

Egypt has exterminated desert areas that may be considered a resource to be used. Other possibilities are offered by the oasis and areas around the cities of Cairo and Alexandria; interesting is the phenomenon of the New Towns, i.e. new productive and residential settlements. Along the Nile (3000 km in Egypt), there are many cities, temples, and archaeological site; in the delta is located the city of Alexandria.

#### 4.2. PUBLIC PROJECTS TO PROMOTE TOURISM IN EGYPT

With respect to the role of tourism in the national economy, the Ministry of Egyptian tourism has prepared a program to increase the competitiveness of the sector.

The General Authority for Development of Tourism<sup>8</sup> in his plan, which cover up to 2017, wants to increase tourism, increase hotel availability, income and employment. The Authority provides assistance of international and national experts contributing to the development of integrated tourism; provides economic support and fiscal incentives (exemptions from taxes for a 10 years period) in order to attract investors in the infrastructure field.

The development strategy aims at [2]:

- changing the role of the public sector by making it more efficient and by encouraging and expanding the presence of the private sector;
- developing an appropriate legal and institutional environment;
- providing the needed infrastructure to areas in order to be develop;
- protecting the environment;
- identifying priorities for the development process.

Interesting is the marketing public policy within a State "marketing plan". This plan consists primarily of a promotional campaign that has as its goals the world markets, for 24 foreign markets in addition to the Arabic region and the internal market<sup>9</sup>. The promotion also carries out on internet<sup>10</sup>, tourist publications, guides and campaigns based on public relations<sup>11</sup>. What really matters is a rational combination of land development with market strategies.

Egypt is implementing a specific program for the purpose of promoting tourism for the period 2006-2011. This program tends to encourage private sector investment by creating job opportunities for young people in projects within national tours. The program also tends to increase the number of tourists to 14 million, 140 million nights and the hotel capacity to 240 thousand rooms.

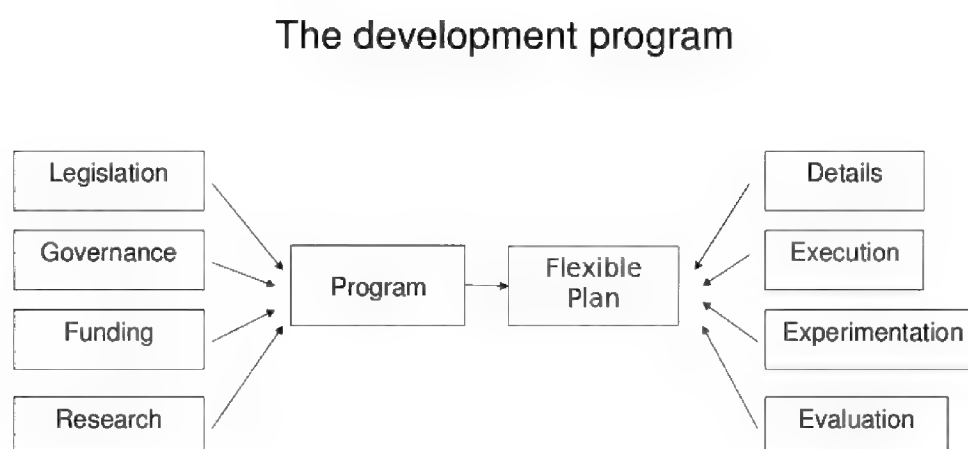
New tourist settlements have been created in remote and rural areas of the country resulting in an increase in the Egyptian tourist sector.

During the period 1992-2006 started around 557 tourism projects with a hotel capacity of 40 thousand rooms. 51 tourist centers that have specific characteristics and receiving relevant incentives have been programmed.

In 2008 the country has decided new projects in South Sinai, in the Red Sea, in the Gulf of Suez and elsewhere always, largely, a tourist resort type. These projects in addition to other possibilities such as routes that travel history of Islam, villages and new tourist cities.

A strategic project for the 2022, has been proposed to increase the number of tourists to 25 million, reviewing the existing settlements.

In general, for an enhancement program is important examine tourist legislation, governance, available funding and research activities. The program must use a flexible plan articulated in detail, with the possibility of testing, in order to offer the best execution and the subsequent assessment.



**Figure 1.** The development program: about here

#### 4.3. CULTURAL TOURISM IN EGYPT

Cultural tourism, in particular, is certainly the most important kind of tourism in Egypt, taking into account the archaeological finds dating back to the era of the Pharaoh, ancient Greek and Roman, Copte and Islamic. Archaeological tourism and cultural tourism represent the traditional form of Egyptian tourism. However, despite the fact that different types of tourism exist, the cultural one remains the original component of tourism in Egypt.

In addition to the sea tourism, therapeutic tourism, religious tourism, adventure tourism, ecological tourism<sup>12</sup>, and the tourism related to sports, other type of tourism are growing in importance. An example is, in the context of cultural tourism, archaeological tourism, urban tourism, architectural tourism and those type of tourism with an interest in Museum, history<sup>13</sup>, cities of art relevant are also the international conferences with aspects of touristical type<sup>14</sup>, cultural events linked a show such as festivals<sup>15</sup>, music, visual arts such as cinema and television, folklore and prose.

It is possible to enhance tourist supply by combining different types of cultural heritage, by preparing projects involving the territory and the local community through the logic of cultural districts.

## 5. THE CULTURAL DISTRICT OF ALEXANDRIA

Cultural tourism is mainly a urban tourism [12]. In fact, in most of the towns are concentrated population, cultural services and products; the city retains the history of the cultural heritage and traditions of each country. Urban tourism differs from other forms of tourism for the presence of some significant connotations relating to accommodation, to the length of stay, to the organizational modalities and to the places explored.

Egypt is divided into 29 governorates. Moreover, governorates may comprise just one city as in the case of Cairo and Alexandria. A governorate is administrated by a governor appointed by the president of Egypt.

Alexandria was founded in 331 BC from Alexander the Great, hence the name. Ptolemy did achieve the Lighthouse, the Museum and the Library, main canthers of culture of the Hellenistic age.

Alexandria currently counts 4,1 million inhabitants, the area is 2,679 km<sup>2</sup> and is divided into six districts. It is the second most important city of Egypt, broad port on the Mediterranean that serves 80 % approximately Egyptian Foreign trade.

The tourist flow, attracted by the beaches, the remains of Graeco-Roman civilization and cultural institutions in the city, develops throughout the year.

To program interventions for the development of cultural tourism is, however, necessary to check to see which are the resources of the territory concerned: the city of Alexandria.

Alexandria was one of the most important and wonderful cities of the ancient world. Many are the ancient monuments and the recent tourist attractions which include the mosques, Pompey column, Roman Baths, the Catacombs, Ras as-Sauda Temple, Koam a-Shuqafa, churches, castles, the Roman Theatre, maritime archaeology artefacts, museums: Alexandria Aquarium, the Graeco-Roman Museum, the Royal Jewellery Museum, the Museum of the Fine Arts, the Cavafy Museum, the Alexandria National Museum, Islamic markets, the ancient palaces of different architectural styles and the gardens; interesting also the colonial and post colonial buildings.

Alexandria has important cultural institutions. Among others: the modern Alexandria University Center for Conferences, the Alexandria Symphony Orchestra, the Archaeological Society. Higher education institutions are: Alexandria University, the Arab Academy for Science and Technology and Maritime Transport, the Higher Institute of Technology (AIT), the High Institute for computer & Information Systems (HICIS), Pharos University in Alexandria, Université Senghor.

The new library, inaugurated in 2002 and sponsored by UNESCO, was erected on the site of the pre-existing destroyed library, this in order to invoke the ancient cosmopolitan character of Alexandria; the impressive building is intended to become the main international centre of studies and research of the Middle East.

It is also important to mention the Montazah Palace Gardens, collection of gardens in one of the first Royal palaces, with hotels, restaurants, chalets, Antoniadis Park has also waterfalls. Other places of entertainment: Shallalat Gardens, Alexandria Zoo, Green Flora, Fantasy Land, Marina Village, Marmoura Beach, Alexandria has four football stadium.

Total arrivals to Alexandria in 2006 were 374.561 and 110.687 represented by tourists.

Alexandria is not competitive compared to other Egyptian reality, such as the Cairo with 2.356.731 tourists, or the Red Sea with 2.462.679 tourists and the Sinai with 2.773.100 tourists. It is, however, a different type of tourist that knows how to appreciate a less known reality and culturally sensible tourism environment.

Examination of the cultural reality of Alexandria fits into a district logic which have identified potential linked to urban spatial concentration of heritage significance for tourist development focused on cultural resources and activity. The geographical concentration makes it necessary to identify the situation and the needs of the territory. In the cultural tourism sector is found, then, an homogeneous area with a tourist offer integrated with cultural services.

The cultural district represents a model of local development auto-sustainable, independent and sustainable, with integration of processes of territorial cultural heritage.

The cultural district poses at the centre of the analysis the cultural good, even if other resources of the territory must not to be neglect, such as the environment, infrastructure and services related to tourist reception, firms undertakings activities related to culture. Those are mainly artistic, natural resources and transport services. Very important are the local public authorities interventions in favor of cultural tourism and district, officially recognized in order to promote the development of the economy and culture in the area defined for a greater attractiveness.

The cultural district goals are:

- protection and conservation of the territorial cultural heritage as a collective resource from the perspective of a sustainable enhancement;
- integration of historical, cultural and environmental resources for specificity safeguard;
- establishment of a system of reception with qualitative and quantitative standards according to potential demand (supply and demand sustainable);
- development and the enhancement of "contextual knowledge" in the field of knowledge, technology and research to create an added value of the capital of culture;
- support of territorial social identity;

- development of human resources to promote innovation in the cultural processes;
- specialization of the supply;
- increase entrepreneurship linked to the sustainable use of the cultural heritage;
- promotion of a territorial mark, identifying products and territory.

The focus is, then, on the territory characterized by a cultural specialization and the presence of cultural activities, such as Alexandria.

The preferred approach is the enhancement of cultural heritage resources of the city of Alexandria involving the active of local partners coming from different experiences.

The programming tasks must meet several entities especially local authorities, business and cultural institutions for cultural and economic development of the district. Funding should, therefore, be mixed: public and private.

It is necessary to establish precise strategic objectives and reasoned proposals that offer activities, responsibilities and methods of intervention.

The benefits of this project are linked to the relationship between culture and economy, in particular, given the benefits accruing to cultural tourism in a city like Alexandria certainly attractive from a cultural point of view, but not sufficiently inserted in traditional tourist circuits.

## 6. CONCLUSION

The theme of cultural tourism as a factor of economic development is important for some countries, such as Egypt, rich of history and cultural heritage.

It has been often emphasized the positive effects of also cultural tourism on economic growth and employment; however, we must not remain silent certain risks such as the destruction of the environment, the overcrowding, the dependency from major industry.

In Egypt the situation of tourism is differentiated in various areas of the country; encouragement of sector programs are in place, however, must safeguard, a rigid approach of sustainable development, culture and the environment.

As regards, in particular, Alexandria, it comes to maintaining character multicultural city threatened by the fast expansion of the suburbs in a really strong demographic growth.

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<sup>1</sup>Culture can be considered as a good with specific characteristics.

<sup>2</sup>International Tourist Association, 1951.

<sup>3</sup>Average stay index is the ratio of attendance and arrivals in different tourist facilities.

<sup>4</sup>It is important the description of the context as well as to record the change over time: images of virtual reality and technical date have been used.

<sup>5</sup>The public must be informed through websites, magazines and events for the promotion of tourism.

<sup>6</sup>WTO (1997) says that in the area of the Mediterranean the total volume of tourism is decreasing, even though the cultural tourism increases with a percentage of 15 % per annum and a percentage equal to 37 % of the whole tourism market.



<sup>7</sup> To protect the national economy, Egypt has imposed a local participation to foreign companies that invest in the sector tourism, trying to defend local businesses [4].

<sup>8</sup>The General Authority for Development of Tourism was set up by the Presidential Decree No. 425 1992.

<sup>9</sup> Cooperatives in conjunction with the Ministry of Education are used for the promotion of the internal market. Domestic tourism represents a promising segment attracting the Egyptians themselves to visit their country.

<sup>10</sup> A portal in seven languages which contains numerous sites rich in information has been created inside of promotional tourism policy. The project is also aimed at foreign tour operators for the promotion of new products.

<sup>11</sup> The 2009 was chosen as the year of the tourism promotion between Egypt and Japan.

<sup>12</sup>Egypt has 27 nature reserves which are also a source of income.

<sup>13</sup> This type of tourism is interested in subsequent eras of civilization that have taken over the centuries.

<sup>14</sup> It is a significant dimension of tourism that brings extensive financial resources and shows a strong growth.

<sup>15</sup>The festivals are an important tool to attract tourists and media attention. Numerous festivals, movies, music and sports events are organized in Egypt.

# ON THE ECONOMIC EFFECTS OF CULTURAL TOURISM IN ART CITIES: THE CASE OF “CROWDING OUT”

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## Abstract

Aim of our analysis is to describe economic effect associated to cultural tourism and stress the hypothesis that improving cultural attraction can foster local development, suggesting that a massive tourist flow can determine not only positive externalities in terms of economic impact but also a negative effect due to the congestion costs and community rent lost. These consequences proceed from the existence of a possible trade-off between preservation and valorisation of cultural goods in the Italian art cities. From one hand, their conservation and preservation represent a significant and symbolical feature of “community value” (expressed as merit wants) and, on the other hand, their valorisation attracts a considerable number of visitors and, subsequently, a profitable economic activity. These two aspects are not always pretty compatible, especially when tourist arrivals exceed certain levels and produce the functional transformation of the historical centres. Moreover, the fruition itself can be enjoyed at different levels of quality: we further investigate how the “type” of visitor (more or less educated, art lover or simple tourist etc) affects the quality of visit and, subsequently, the welfare effects linked to the cultural fruition. This latter aspect recalls the debate on the possibility of making admission to museums or other cultural institutions completely free.

We conclude with some observation in terms of “cultural democracy”, questioning the effective policy implications of a democratic admission to museum and/or other cultural institutions.

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**Keywords:** heritage, merit good, cultural tourism

## 1. INTRODUCTION

Cultural tourism is considered from government and business official as a strategic factor in developing the local economy and contrasting unemployment. The current emergence of “cultural tourism” [1] instead of the “culture of travelling” and the management of cultural resources through superimposed “cultural districts” instead of context-based planning frameworks able to reflect stratified “community values”, testify a way of appropriation of the cultural heritage which seems to undervalue the deepest meaning of it.

In the last years, if the attention of local authorities and cultural institutions has been called about the managerial organization of museums, archaeological sites and historical centres, now the mass fruition of cultural goods is highly criticized, considering that “a misleading advertising” has been done.

We start our analysis describing the phenomenon of “cultural tourism” and stressing the hypothesis that boosting cultural attraction can necessarily improve the economic conditions of a city, suggesting that a massive tourist flow can determine not only positive externalities but also undesired external effects.

We perform our analysis emphasizing three main economic effects generated from the presence of cultural heritage in art cities:

- First, the existence of a possible trade-off between preservation and valorisation. From one hand, conservation and preservation represent a significant and symbolical feature of “community value” (expressed as Musgravian merit wants) while, on the other hand, valorisation attracts a considerable number of visitors and, subsequently, a profitable economic activity. These two aspects are not always pretty compatible, especially when tourist arrivals exceed certain levels and produce the functional transformation of the historical centres.

- Second, the congestion effect. Massive tourist flows, attracted by a well preserved heritage, can generate negative externalities as recognizable in augmented traffic, higher costs of living, new business activities aimed at satisfying only tourists preferences. Is it possible that this kind of effect, that is congestion, notwithstanding the positive level of tourism revenue, can diminish the community value.

- Third, cultural economics analyses the demand mostly as a function of revenue and education [2]. Our considerations change this traditional formulation: we describe the “crowding out” effect as a further external effects linked to the characteristic of the consumption of cultural goods.

Being the fruition enjoyed at different levels of quality, we investigate how the “type” of visitor (e.g. more or less educated, art lover or simple tourist) affects the quality of visit and, subsequently, the welfare effects linked to the cultural fruition. This consideration proceeds from the fact that the good “culture” comes from relational needs [3], which are derived from social interaction. At this point, a further issue is raised about the possibility of making admission to museums or other cultural institutions completely free. We consider this choice a question of “cultural

democracy” that we analyze by means of traditional instruments of welfare economics and, again, raising the idea of merit wants.

## 2. CULTURAL TOURISM AND THE EFFECT OF CROWDING OUT

The emergence of cultural tourism and its defining characteristics must be studied in the context of the development of the contemporary tourist sector and its need for diversification. In fact cultural tourism “can be attributed to the growing importance of the new urban middle class with a high level of education, an interest in experiencing something different from the usual tourist traps, and a desire to learn something rich in cultural, symbolic, spiritual or historical content” [1, p. 187]. Cultural tourism hence is strictly connected to the emergence of an higher demand for leisure mostly directed to the fruition demand of cultural heritage. The phenomenon is so huge that leads to the development of a free time industry offering hospitality and attractive cultural itineraries (package tours). It’s progressively rare that a single individual organizes his own vacation but he prefers to turn to a tour operator, thanks to the simple means created by internet. As already written [4], this leads to the disappearance of the travel, meant as a process of initiation to the cultural life, in favor of a mass consumption as a repetition of the same action all over the world.

If it is true that a cultural tourism demand is becoming more consistent, then the regions that are more attractive in that sense must be organized to be effective in drawing this kind of tourism. If the massive tourism that we find in some Italian art cities can be attributed to a high and well preserved heritage that is the cause of the high level of attraction of that city, however, another effect must be considered, that is the negative effect that is associated to massive tourist flows, as recognizable in augmented traffic, higher costs of living, new business activities aimed at satisfying only tourists preferences. Is it possible that this kind of effect, that we name congestion, notwithstanding the positive level of tourism revenue, can diminish the community value and the associated rent.

To describe the possible economic effects associated to cultural tourism we use the concept of “cultural rent”. Basically, this rent is formed by two fundamental elements that are:

- 1) the tourism revenue, resulted from the visitor’s stay, that is the sum of all tourists expenditure (restaurants, hotels, shops);
- 2) another component of the cultural rent is the community rent that follows from the Musgrave’s community value that is a complex value, resulting from multiple specific characteristics (that is the sum of merit and public features of the goods).

We know that Musgrave coined this concept: in few words he says that a merit good is a commodity which is provided to an individual or society apart from individual preferences, because it refers to merit wants that arise from community traditions, values or customary practices and express group preferences embedded in historical, religious and ethical traditions, timely defined. As recently Musgrave [5, p.344] points out:” More generally the public sector in a democratic state may support policies not only in response to individual wants (preferences) but also to merit wants which individuals accept as expressions of community values”.

The musgravian concept of merit good and needs include conservation and preservation practices that are entrusted to government in the interest of future generations [5]. Hence, the supply of cultural goods determines an increment of social welfare in the territory, in terms of higher education of the civil society together with the restoring and conservation of goods and values inherited from the past.

Summing up, the economic effects can be synthesized by the externalities (positive or negative) plus the rent associated to the “community value”.

Cultural economics analyses demand mostly as a function of revenue and education [3]. In our considerations regarding the whole external effects produced by cultural tourism we want to review this traditional formulation. We describe as “crowding out” the displacement effect associated to massive tourist flows that, due to the congestion effect, excludes some visitors from the accession to museums and other cultural institutions. We can imagine different categories of visitors that distinguish for their economic, social and cultural characteristics and that choose to consume cultural goods not only depending on the typology of the good provided but also considering the congestion effect produced in some museums/galleries.

In other words, we are supposing that the characteristic of the good “culture” (heritage) changes according to the way it is consumed. This explains why some visitors are literally thrown out by a mass fruition of the heritage that is more led by the imitation effect than by a real demand of higher education.

At this point the consideration of the whole economic effects opens two more issues that are about the effective meaning of cultural democracy and its relation with the concept of community value.

## 3. CONCLUSIONS: SOME REFLECTIONS ON CULTURAL DEMOCRACY

Recently a question of cultural democracy has been raised [6] that basically concerns the possibility of making admission free to museums.

We think that the problem of “democratization” of heritage is mostly a question of merit good. Hence, it seems necessary not to focus on the binary choice (free yes or not) but to discuss of policies for culture recalling some theoretical issues.

The principal justification for public intervention in the cultural domain proceeds from considering cultural goods as merit goods. The public sector in a democratic state may support policies not only in response to individual wants (preferences) but also to merit wants which individuals accept as expressions of community values [5]

Accepting this scope for government direct intervention, on one hand it raises the incentive for consumption of cultural goods and performing arts as well as for their preservation and valorisation, on the other hand it makes necessary the definition of state's preferences to be ordered to produce their policy implications.

In the case of free accession, the decision of free admission must be taken after a cost benefit analysis by means of which evaluating the welfare effects of this kind of policy.

However another aspect that we want to recall is that cultural goods not only have the economic characteristics of mixed goods and merit goods but they have also some specificities in term of use/fruition: the good "culture" distinguishes from the fact that, in opposition to the basic needs, it comes from relational needs, which are derived from social interaction. Being this relational goods "common goods" that ask for a common action also in the act of use, their effect on utility is not directly determined from an increment of quantity but it could be mostly connected to the modalities through which these goods are put into the market.

For these reasons, we think that a democratic admission can't be measured only in terms of an higher number of visitors but also with the sharing level of visit experience in the social context of each consumer.

Considering the crowding out effect, the policymaker must choose not only the amount of resources devoted to valorisation of heritage but also what type of cultural tourism to promote.

The issue below concerns the meaning of cultural democracy: refusing to consider it as "the conquest of the reluctant" [6], but meant as a dynamic process that progressively reduces during the time the formal and essential obstacles to the fruition of cultural goods by all citizens, it implies that the ways and the modalities and not the quantity of consumption have to be selected. In other words, the challenge for contemporary cultural policies is represented by the alienating fruition, that can make museum, even when all physical obstacles are removed, an empty container of senseless objects, like a supermarket in which the single purchases lose in the trolley.

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## **THE CULTURAL POLITICS OF TOURISM, IDENTITY AND HERITAGE: A VIEW OF A MULTICULTURAL ISTRIAN REGION (CROATIA)**

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Over the last 10 years what European cultural policy makers understand by ‘culture’ has changed in very significant ways. It is now commonly argued that culture is not just a marginal activity but necessary and integral to the creation of European identity, and that it includes both tangible and intangible cultural heritage. Culture is now recognised as a drive for creating the sense of identity. At the same time culture and cultural heritage have been recognised as one of the major sectors of the European economy and an essential part of tourism. More and more countries are making strenuous efforts to present themselves as desirable destinations for foreign visitors. In order to be visible on the global market, these countries undertake various promotional activities to represent their cultural heritage by drawing not only on the pre-existent resources, but also on the public discourses implemented in creating and maintaining the national identity. On the other hand within the context of globalisation, regional cultures are increasingly pressured but become more important in making a distinctive offer to the tourist markets.

The question of how to translate a local site into a global/European or national site, and how to translate European heritage into local diversity becomes crucial, as selections of what to present often conceal contestations of cultural values and heritage traditions.

This paper addresses the impact of these policies on cultural tourism of a multicultural heritage city of Pula in the Croatian region of Istria. Through the analysis of the discursive space of intersectionality within this city’s ways of responding to the contemporary European issues on multiculturalism, it attempts to explore whether the current trends in cultural policies regarding the construction of European and national identity/culture are trying to homogenise multiculturalism, and if so, how this homogenisation reflects on cultural tourism through manipulating cultural heritage for short-term economic, political, or cultural advantage.

# SUSTAINABLE TOURISM: A “MEDITERRANEAN CHALLENGE”

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## Abstract

The interaction between socio-cultural, migratory pressures and technological innovations over the centuries has shaped Mediterranean civilizations: the governance of these phenomena, which now take a quick and chaotic rhythm of growth, is the "Mediterranean challenge" to which Europe can not escape.

The growth of tourist flows – in combination with other forms of mobility, covering goods, services and capital - is an important factor which contribute to an acceleration of integration between different regions of the Mediterranean.

The optimal results of integration of tourism development in the local area are achieved, in fact, only with new targets and new tools of governance for the mobility of tourists: that is, with appropriate measures to encourage a better distribution of tourism in time and space.

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**Keywords:** Mediterranean Tourism, Sustainable Tourism, Cultural Heritage, Globalization, Integrated Relation Tourism.

## Introduction

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The growth of tourist flows – in combination with other forms of mobility, covering goods, services and capital - is an important factor which contribute to an acceleration of integration between different regions of the Mediterranean.

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## 1- Mediterranean Cultural Heritage and Globalization

The most authoritative and recent historical and sociological analysis (Fukujama, Huntington) is oriented in confirming the hypothesis that the original pressure for the processes of globalization is of cultural nature: the modernization of "life styles" is only a economic sub-product of cultural globalization. The import of goods follows the import of culture, not viceversa. The migration from country to urban space is the demonstration of this phenomena.

It is really hard to give a mean to the "modernization" - above all if it is considered to be opposed to the "westernization" - understanding both as the alternative strategies for the economic and social development.

The beginning of globalization is characterized of a cultural boost that changes the needs - above all for the exceeding the "symbolic consuptions" - while the cultural adaptation, that has operative effects (that is the behaviour concerning the issue of employment and the adoption of innovative tecnologies), is very low.

The cultural pursuit implies both growth and economic dependence that worsens the frustration and mistrust: and further provokes cultural dependence given place to a "vicious circle".

Different is the "cultural resistance": the deeply permeated religious societies (Indian, Islam) are stronger than those where religion was imported (Africa, Latin America).

Is it possible to realize a deep transformation, oriented to "modernity", without twisting the traditional values, thus without copying "westernization" schemes? It is so hard to answer at this question but these two concepts, "modernization" and "westernization" are often confused.

With "modernization" we intend an aspiration to a wealthy "life style" based on a productive structure that is permeated by advanced technology and localized in an urban area. The production is organized in structures of great dimension, where the organization is hierarchically aimed at profit maximization

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With “westernization” we intend the adoption of ethical, individualistic and secular values – in opposite of the values of tradition – that come out from the rational thought purely: in this way it can reach to manage the society with innovative principles that put into above all the role of family and women as well as civil rights (freedom of thought, expression and worship).

The management of environmental resources becomes “modernized” in conflict to traditional culture. This old culture, that was derived from the religious beliefs (sacredness of nature), is now substituted by an anthropocentric strategy in which the environment is preserved only for the welfare of the future human generation.

In this dramatic confrontation between the western world and niche societies still not completely “globalized”, appears interesting the intentions of some countries to follow economic “modernization” refusing “westernization” as it has been defined above.

## **2 – Imbalances and conflicts in the use of natural and cultural resources for tourism**

The wicked interweaving of demographic tensions, food deficit and environmental degradation pervades a large part of the Mediterranean area: this area is therefore considered a “laboratory” particularly suited to analysing the gap between the North and South which increasingly characterizes international relationships (Latouche S., 2005).

As for the tourism industry on a global scale - but especially in that microcosm of religious, ideological, racial, economic and social conflicts is the Mediterranean area - the choices of technology and environmental protection are also becoming a crucial factor in outlining future scenario.

In recent years the European tourism sector was characterized by two phenomena: firstly the loss of competitiveness of seaside destinations, hit by competition from tropical developing countries, and secondly the rapid expansion of new market segments such as ecotourism and tourism related to cultural events in the “city of arts” (WTO Commission for Europe, 2004).

Overall, the most notable feature of the tourism sector remains both the strong concentration of the tourism supply in sea side resort areas, in cities of arts and the persistent backwardness - beyond qualitative and quantitative - offered in the marginal areas and islands.

In the tourism areas of the Mediterranean, often particularly fragile and vulnerable to the negative impact of mass tourism, environmental sustainability requires a fundamental restructuring of tourism activities and so should be more differentiated in the variety of destinations, in order to use tourism as a tool for policies for the economic and social development of marginal regions (Unep-Pan Blue, 2008).

It should be noted that the environmental costs related to the mobility of tourists could be significantly reduced if a objective and comprehensive information spreads out to all tourists; this information should highlight the benefits in terms of actual enjoyment of cultural and environmental resources of dilution on holiday throughout the year, avoiding the concentration during periods of so-called “high season”. The “short-sighted and rapacious” use of environmental and cultural resources for tourism often creates imbalances and conflicts of various kinds.

Economists have analysed, from many perspectives, the relationship between residents and tourists: recently they make use of the theory of games. This theory has examined the two communities of tourists and residents, by examining their behaviour and their relationships. Furthermore, the conflict between two players is in fact set by the interests and preferences of each group. (Bimonte S., Niglia G. e Punzo L.F., 2006)

From the study of the behaviour of the two communities an analysis of resource use by each group is possible: the pressure on resources by either community exposes them to a conflict that is both inter-community, and intra-community that is within each community.

If it is true that the same flow of tourists has different effects in relation to the different communities that receive them (the so-called subjective element), it is also true that there are objective factors - the carrying capacity, negative externalities (such as crowding and congestion) - that affect the relationship between residents and tourists. The latter, in fact, for their way of doing and acting were generally treated, like a player who plays once and leaves the game because he doesn’t repeat it under the same conditions (Bimonte S., Niglia G. e Punzo L.F., 2006).

Tourist-players don’t behave like players who respect the rules, such as reputation, which are specific to those who participate in any game. Also the tourist, who comes back to the same location, has difficulty in taking an interest in socio-environmental problems of the host territory, and for the brevity of his stay and for changes in social conditions which had occurred in the previous visit.

The drawing and use of resources for tourism activities generate a number of costs, and the various benefits are spread among the residents and tourists.

The contrast between the two communities comes out especially during the development phase of the “life cycle” of the tourist product, a stage in which tourism activities permeate the economic system of the territory, causing a “displacement effect” in comparison to other economic activities because of the high demand of resources necessary to meet the needs of the many inflowing tourists to the village.

What is more, it is essential to define the rules and objective criteria in order to limit, constrain and control the drawing of resources taking place in a given area, where local and private interests could outweigh the benefit of the community.

Therefore, the general criteria set a balance between the private marginal benefit and public marginal benefit in the use of public resources for tourism. It is possible to set the point of equilibrium using three different criteria.

With regard to the economic issue, it is necessary that the resource management criteria can satisfy:

- a) economic efficiency: this criterion requires a resource management, which maximizes the production of services and minimize the use of those resources, for the same product, avoiding waste;
- b) the economic viability of investments: this criterion requires investments that create a sustainable heritage, leaving it to future generations and thus improving the initial situation;
- c) internationalization: when resource management is internationally competitive, it is possible not only to attract foreign capital but also provide a interesting model for new types of tourists.

Regarding the environment issue, resources must be used in respect of the following criteria:

a) minimizing the adverse environmental impact in new investments: the use of resources, while reducing the stock, should not make irreversible damage in the environment. The new investment will select only those resources whose use does not permanently diminish the environmental quality of the original land but allows the establishment of manufacturing processes without changing the natural and cultural environment. The new investments, thus minimizing the adverse effects on resources, should not exceed the "tourist carrying capacity", namely the ability of land to accommodate a maximum number of people in a time unit, in one hand, without compromising the economic viability and environment and, on the other hand, without reducing the satisfaction of tourists;

b) the rehabilitation of marginal areas: the use of new resources should not be concentrated in central areas, but should be facilitated in those marginal regions where resources are higher in quantity and quality than the areas already developed; this choice would not only develop the depressed areas, but mainly reduce the congested areas.

Another area where regulation is needed, in regards to social issues, because new investment has a positive and negative impact on community relations. To ensure the flow of benefits to the local community, it is important to apply the following criteria:

a) affirm the principle of solidarity between different groups in society as useful when comparing different needs and traditions. This criteria is applied, for example, in places where food is an element of tourist attraction. To ensure the success of this type of tourism, the employers in general or capital investors should interact with that part of the population who knows in detail the resources of the region;

b) ensure the development of local knowledge to improve on a permanent basis, the use of existing resources and make more people aware of local resources and the potential of the territory. An important contribution, in such meaning, can be provided from the enforcement of the "relational tourism". The normative interventions and the financial incentives of the European Union can give a substantial contribution in this direction: in particular the policies for transport, environmental protection and development of the marginal regions supply instruments for cross-sectional initiatives oriented to facilitate the intercultural exchanges and the comparison of "styles of life" between residents and tourists. The mixing of activities among local and national authorities and international agreements can increase in some cases the reasons of conflicts.

The protection for the cultural and environmental goods of high value in the city centres of the "cities of art" is this case. The needs of the residents - in particular mobility for the daily movements for working - enter frequently in conflict with the demands of tourist mobility. Tourists, in fact, circulate in the residents areas, but they have various times and rhythms. Generally the national authorities are highly sensitive to the protection of the cultural and environmental quality to the historical centres; on the contrary the "subsidiarity principle" can determine activities with short-sighted and rapacious exploitation mostly for commercial and tourist aim of the territory. It has happened in the South and North river of the Mediterranean for the tourist pressure not only in the "cities of art", but also in the bathing areas: the strategies of the local authorities, inspired to "short-sighted" interpretation of the "principle of subsidiarity" have contributed to taking place of environmental destruction and "cultural genocide".

All the criteria can be more easily adopted when they are absent of the restrictions that affect the development of local communities. The use of resources can happen in a sustainable manner not only by applying these criteria, but moreover by suppressing the constraints of the dominant culture and overcome some limitations imposed by both man and nature.

The use of natural and environmental resources before tourism development, may also create restrictions on mobility and the growth of tourism. In one area, in fact, where the soil and air resources are intensively used for the carriage of goods by road, the start and the subsequent increase in tourism demand overloaded road infrastructure with a consequent high level of congestion and pollution.

In many Mediterranean destinations the adoption of new management criteria is the right measure to take to improve and restructure the whole tourism supply, this is true both for it's public features - transportation, fees and training - and for private factors. In particular an important tool in a hospitality industry is the level of professionalism of the hotel managers, the management of the e-booking system, the improvement of tourism product marketing and not just improvements to individual hotels.

### **3- Sustainable tourism as a tool of intercultural dialogue: potentialities and restraints.**

As people move from place to place their different cultures are carried along with them. When discussing progress and peace historians widely agree that this phenomenon has usually been assessed in positive terms.



In theory it would be difficult to counter this evaluation with clearly valid arguments. However, historic experience whether from antiquity or from more recent times can induce serious doubts.

The acquisition of philosophy and Greek art by the Roman Empire have often been cited as positive examples of intercultural exchange, as is the harmonious synthesis of byzantine refinement with Arab creativity during the reign of Frederick the second in Sicily.

And yet historical evidence often underlines the fact that some 'intercultural dialogue' experience has led to a number of disastrous results: the most clamorous examples coming from the 'colonisation' of Latin America and Africa, but neither can the inclusion of India into the British Empire be evaluated as entirely positive as the total consequences are yet to be understood.

From the point of view of the Mediterranean area recent centuries have seen the intercultural dialogue evolve into a one way exercise of 'modernisation': Western European countries have colonised in every sense those to the south with their supremacy of technology and military know-how, provoking in the colonised cultures sentiments of frustration and revolt. Cultural frustration has been at the root of attempts to chase after modernisation, with mostly modest results and for the most part concentrated in petrol exporting countries able, if only partially, to attempt to fill the technological gap.

Incidents of revolt with various degrees of violence have been successful in gaining national independence with, however, serious limitations in levels of political or economic autonomy.

There are usually two important aspects to any intercultural dialogue. On the one side there is communication and the exchange of ideas, on the other there is often mass movement of people. It would be imprudent to come to the conclusion that because intercultural dialogue has this double effect there is always the tendency for economically and technically stronger cultures to provoke a form of 'genocide' in weaker cultures. However, examples in various epochs and geographic situations show that this hypothesis merits close examination with careful interdisciplinary research.

It can be seen that intercultural exchange appears to be a source of reciprocal enrichment only under specific conditions 1) reciprocal curiosity 2) equal dignity and respect 3) renouncement of missionary zeal.

1- Reciprocal curiosity. The movement of people is not always associated with that mental flexibility that arouses curiosity for the society visited. In the case of travel for the pursuit of specific goals, for example traders with the aim of profit, or the conquest of colonising armies, religious conversions for missionaries, the venture is always preceded by a period of explorative investigation of a cultural nature. In the case of tourists, as opposed to travellers, however, this exploration is often absent, given that the main objective is the immediate enjoyment of the country's resources whether it is nature, the climate, landscape, in some cases various forms of eroticism, even gastronomic interests or a liking for folk law, which is often adapted to satisfy the clients' expectation. As far as the local population is concerned curiosity is a spontaneous phenomenon at least in the initial stages. One thinks for example of the behaviour of the South American Indians and their welcome to Columbus or that of the Sicilians in the recent Fifties. The perception of the foreign visitor as a threat to their own identity or their own economic interests comes at a later stage and can be used and manipulated for political or religious ends. The present 'closure' in fundamentalist areas, not only to immigrants but to missionaries and tourists, is an obvious sign that diffidence for any form of exchange or dialogue prevails over natural curiosity.

2- Equal Dignity. To be able to determine the requirements for a positive flow of intercultural dialogue it would be necessary to face a very complex and controversial problem, too difficult to deal with in these pages. The problem is one of 'cultural hierarchies' In this present age cultural globalisation is being driven by rapid progress in computer technology and in this context it is undeniable that western culture has become the benchmark for all those who aspire to modernisation from whatever continent, including women to a large extent. We can therefore affirm that the mobility of people, above all in the form of mass tourism is a vehicle for the transmission of western culture. Western culture considers itself superior and even by some to be the 'definitive' culture and there is the arrogance of people like Fukuiama who along with his innumerable followers proclaim that we are at 'the end of history'.

3- Renouncement of missionary zeal. Even in the case of enlightened intellectuals like the Jesuit Matteo Ricci in China missionary activity is generally characterised by a manipulation of culture, geared at proselytising. Without doubt this type of cultural dialogue has also numerous positive aspects. There is a willingness to recognise reciprocal similarities and differences and a readiness to take part in discussion with a number of interlocutors, and in establishing a common language.

However, in recent years a certain type of hazardous missionary activity has been asserting itself and this comes by way of mass tourism, if mostly without conscious intent.

With the ostentatious signs of his culture's economic opulence and the 'modern ways' in dress, technological gadgets, uninhibited sexual behaviour, the tourist constitutes an anthropological benchmark against which the poor residents of the country he is visiting have little to counter with if not their own frustration. This frustration tends to express itself in either violent animosity or degrading servility.

In the last decade of the Twentieth Century various totalitarian regimes, whether communist or Islamic, have tried to hold back mass tourism by attempting to canalize it towards various heavenly beauty spots. These beautiful places

are under special surveillance, almost like luxury ‘concentration camps’, and tourists are isolated from the local population.

The lack of success in such attempts indicate that this is not the correct strategy for a reduction in the negative cultural impact of mass tourism. Rather there should be new possibilities for tourists, grouped together under the heading People Related Tourism. This would be a far more promising proposition if enriching encounters are to be brought about between cultures which are, as yet, profoundly diversified.

The ability to train tourist operators to be aware of both the potential and the risks connected with an expansion of such people related tourism is an aspect which cannot be ignored in this new Mediterranean challenge.

### **Conclusion**

Since time immemorial the challenge for the Mediterranean region has always been characterised by the encounters of different cultures in a multiple geographic crisscrossing where strongly differentiated cultural orientations tended to either fight each other or enrich each other.

The outcome of the interaction nature/culture is highly influenced by the form in which the movement of people takes. In the past centuries the travels of pilgrims and traders have favoured a peaceful reciprocal enrichment of cultures and economic interests. During the last decade however the prevalence has been on the movement of immigrants and tourists and has led often to conflict. These conflicts have assumed different characteristics depending on whether they take place in urban or coastal areas.

In cities the flow of poor immigrants from countries to the south of the Mediterranean basin has accentuated the degradation in some town centres of great historical value as well as in the suburbs. In coastal regions especially those with exceptional natural beauty the phenomena of mass tourism has provoked unsustainable and at time irreversible damage.

It is obvious that any intercultural dialogue cannot be allowed to spread haphazardly and unchecked but must be subject to order, whether on the level of government intervention or locally, in both cases with reference to the principle of financial support.

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## **ASSESSMENT OF THE ECONOMIC EFFECTIVENESS OF THE IMPLEMENTATION OF STRENGTHENING OF REINFORCED CONCRETE BEAMS WITH CARBON FIBERS UNDER DINAMIC AND STATIC LOADING**

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The reinforced concrete beams are one of the basic elements in the multiform constructive structures. The different kinds of reasons provoke the necessity of construction strengthening and rehabilitation of its bearing capacity. The advanced civil engineering practice is in never-ending prospecting of probably most effective methods for the solving of the actuality problem.

That was precisely enforces and the request of alternative, advanced methods for strengthening and rehabilitation of reinforced concrete beams.

The current paper presents the organization of the implementation of experimental strengthening of reinforced concrete beams with application of advanced composite materials (carbon fibers) under effect of cycle and static loading, as well as and economic analysis of the strengthening methods.

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## TOURISM AS A TWO-SIDED COIN: NEW CONSIDERATIONS ON SOME ASPECTS OF TOURISM AND HOSPITALITY FROM GRAECO-ROMAN EGYPT

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**Keywords:** Graeco-Roman Egypt, Tourism, Hospitality, espionage

### Introduction:

Often wonder, what calls a person for travel to visit somewhere? What calls him to repeat his visits many times? What factors would make any country to be ranked as a tourist destination? Is the purpose of tourism and travel the customary for tourism in its general terms? Or there are other ulterior motives that may lead a nation to be the focus of attention of others? Or in other words, is it possible to have two dimensions of tourism: one is bright, namely the social dimension; and the other is of a veiled political potential?

Following is a review of some aspects which would substantiate tourism in Egypt as early as the Ptolemaic and Roman times and confirm that Egypt might have been listed among the top tourism destinations in the ancient world. On the other hand by examining some of the existing material from a new perspective one will find tourism was a two-sided coin. Upon looking into it, On the one hand it allows both the ordinary tourist and the local community of the host destination a chance to experience other cultures and broadens understanding. Dig a little deeper however, and you find that it might also be frequented by high-ranking foreigners because of some strategic importance. But it would be rather preferable to take the bright side of the image as our starting point.

Egypt is endowed with plenty of sources of prosperity that enabled it to be the dawn of civilization, in which flourished all sciences, theology, and arts. Its thriving heritage, being exuberant of its treasures, motivated the desire to see Egypt's marvels since antiquity. Travelers were dazzled by its gigantic monuments, alien beliefs, vibrant culture as well as its wealth of knowledge.

Historically speaking, the Greeks and the Romans were the most enthusiastic travelers to ancient Egypt. It seems that Classical poetry has provided them with anthologies of Egypt's glorious past that stimulated their sense of fantasy about its splendors and mysteries. Worth mentioning, Homer's twin epics "The Iliad and Odyssey", where the poet as early as the eighth century B.C., praised the Nile, the king's power and hospitality, as well as the immense richness of the country.<sup>[1]</sup> Such fascination with the grandeur of the Egyptian heritage widely frequents further in the writings of classical authors, whose accounts provided unique and often firsthand descriptions, and remained the most reliable sources for ancient Egypt.<sup>[2]</sup> A good deal of information has come down to us by Herodotus who considered Egypt's marvels indescribable and unique in the whole world.<sup>[3]</sup> He was drawn by its exotic flora and fauna along the river and the customs of the people, as well as monuments of the Pharaohs on its banks.<sup>[4]</sup> Following his passion, Diodorus Siculus shed light on the glorious past of Egypt and how far it offered novel to the Greeks with their different ethnic and religious backgrounds to the extent of curiosity about its customs, traditions, weird animals' worship, grandiose pyramids and above all its artery of life – The Nile River that nourished the Egyptians and guaranteed prosperity.<sup>[5]</sup> The same obsession was referred to in the Geography of Strabo who states that the enigma of the Nile, renowned for its undiscovered origins and its flood, had aroused first the fantasy and then the scientific curiosity.<sup>[6]</sup> He also referred to the almighty of the Egyptian priests and their wisdom.<sup>[7]</sup> Such priestly wisdom was also mentioned by Plutarch early in the second century A. D., indicating that the wisest of the Greeks of the archaic age came to Egypt mainly for wisdom.<sup>[8]</sup>

Beside the accounts of visits to the country written in Classical literature, we have more intimate, if briefer, scraps of history preserved on papyri and ostraca, and, most plentiful of all, the visitors' graffiti scratched on Egyptian monuments. All prove beyond doubt that Egypt was a popular travel destination during the Graeco-Roman period however the diversity in travel patterns, motives and practices. To modern categories it seems to be something like "**Tourism**", which is the sum of phenomena and relationships arising from the travel and stay of non-residents, in so far as they do not lead to permanent residence and are not connected with any earning activity.<sup>[9]</sup>

Within these parameters tourists in Graeco-Roman times would mean those who would have flocked to Egypt for the purpose of sight-seeing, or seeking oracles consultation and the wisdom of the priests; or those travelling in quest for health granted by Egyptian deities implored in their healing shrines. The term can be also applied to those throngs of pilgrims headed for Festivals and religious celebrations that were frequently held in the centers of worship for the piety and glorification of miraculous deities. Furthermore, history tells us that Egypt in Graeco-Roman times was also a major target for scholars and savants, who toured the country as seekers of knowledge and global learning. It continued further to be exploited as an extraordinarily productive land by grain traders<sup>[10]</sup> and other merchants haunted with the commercial wealth of the country.<sup>[11]</sup> Conceptually, modern classification of tourists embraces all categories found in Graeco-Roman Egypt: sight-seers, holiday makers, religious pilgrims, invalids in search of health and students or pursuing some other quest, even in the course of employment or business.<sup>[12]</sup>

According to Amaldo Momigliano, Herodotus is the best-known tourist in Egypt in classical times as he '*managed to produce a very respectable history mainly on the basis of sightseeing and oral tradition*'<sup>[13]</sup>. His itinerary in Egypt included a variety of sites, namely: Memphis, Thebes, Sais, Elephantine, The vicinity of Buto, the Pyramids of Cheops, Chephren, and Mycerinus at Gizeh, Heliopolis, the Labyrinth of Amenemhat III at Hawara in the Fayum, and the Pelusiac mouth of the Nile.<sup>[14]</sup> Some other sites appeared on Strabo's itinerary who finds them spectacles and worth seeing.<sup>[15]</sup>

Regarding the fondness of sightseeing tours in Graeco-Roman Egypt, a surviving papyrus of the first century A.D. has preserved for us the letter of a tourist named Nearchus to his friend Heliodorus [Fig. 1]<sup>[16]</sup>, in which he is telling him about many spots he sought out during his journey in Egypt. He mentions that the object of his tour was to observe the works of men's hands<sup>[17]</sup>. Nearchus states that he sailed up to Syene and to the place whence the Nile flows, and that he traveled to the oracle of Amun of Siwah in Libya. He also carved the names of his friends on the monuments as '*proskynema*' to be remembered always.<sup>[18]</sup>

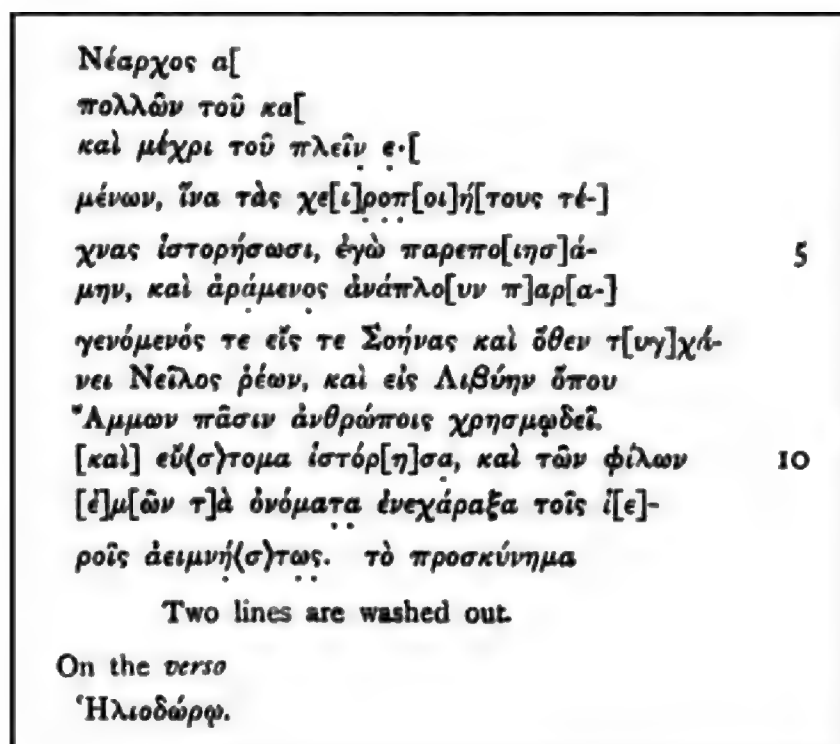


Fig: 1 P. Lond. III. 854  
 A Letter Describing Nearchus' Journey up the Nile

"Nearchus ... Since Many [go on journeys] and even [betake themselves] to a journey by ship, in order that they may visit works of art made by hands, I have followed their example, and having undertaken the voyage up the stream have arrived at Syene, and at the spot whence the Nile happens to flow out, and at Libya where Ammon chants his oracles to all men, and I have learned things of good omen, and have engraved the names of my friends on the sanctuaries for perpetual remembrance.

(Addressed to) Heliodorus".

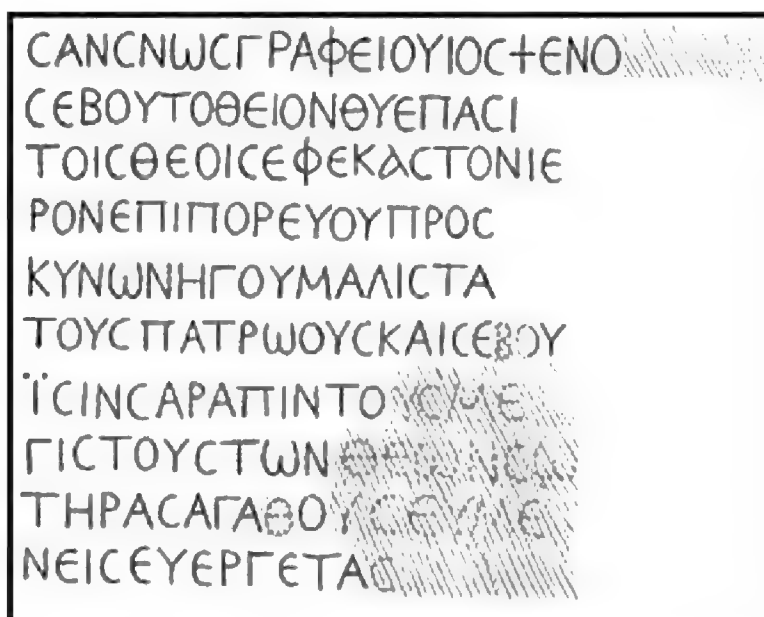
(after, Milligan, G., (1969) *Selections from the Greek Papyri Edited, with Translations and Notes*, reprint, Freeport, NY, pp. 69-70)

This papyrus is of a particular interest since Nearchus, as a tourist, named a form of "**Cultural Tourism**" as his driving force was tourism 'to see the works of art made by human hand'. He was dazzled by his Nile cruise to Aswan (Ancient Syene) and to the first Cataract on the Nile, the very source of the Nile<sup>[19]</sup>. He also travelled to the world-famous oracle of Amun in the Siwah oasis, the venerable seat of prophecy in the first century A.D.<sup>[20]</sup>, where Amun prophesies for all people and proclaims harmony.<sup>[21]</sup> People travelled to such oracular centers throughout Egypt in search of answers and cures.

At the beginning of his letter Nearchus gives indication that the journey up stream was practiced by many other tourists before and thus he follows their example which might also name an earlier form of tourism marketing something like the modern “**FAM Tour**”, which is a tourism industry term for familiarization tour. Such tours are used to acquaint a specific group with an attraction or series of attractions. These are opportunities for tourism leaders to showcase and promote assets for marketing.<sup>[22]</sup>

Still, the papyrus also furnishes an evidence for a common tourist practice, of recording one's presence at a site by carving a **memorial inscription** “*proskynema*” on the most convenient surface at hand. Such travellers' graffiti recorded their experience of the place, its monuments and natural surroundings and hereby achieved their intrinsic interest. Nearchus in his letter states that the *proskynema* (προσκυνημα), that he left behind at every shrine he visited, were not only for himself, but also for his friends; an everlasting and visible act of reverence and appreciation in the form of name inscriptions. It may be relevant to consider here Giovanni Geraci, in his study of the *proskynema* formula, who declares that seeking after immortal remembrance is the prime motive for its users, who perpetuated their names before the divinity in order to possess the eternal blessing of the place.<sup>[23]</sup>

Another tourist named Sansnôs left for us his words engraved on one of the walls of the Kalabsha temple in Nubia [Fig.2]. He visited Egypt about the second or third century A.D., being stimulated, as gleaned from his sayings, to sites with religious significance, or in other words, performing a sort of “**Religious Tourism**”: ‘*Sansnôs, son of Pseno...*, writes: ‘*Worship the divine, offer sacrifice to all gods, make a pilgrimage to every shrine and leave behind a proskynema, hold in especially high esteem the gods, the redeemers, the good, the well-pleasing, the benefactors*’.<sup>[24]</sup> Here Sansnôs' *proskynema* expresses his personal religious piety in a way of propitiating different aspects of local deities in their domains. Such religious dimension of the visit recurred in many other graffiti of travellers headed towards sacred places and recorded in their *proskynema*: “*To the holy place in the presence of all the gods*” (τῷ προσκυνημα του / ἀφ᾽ ἧ τοῦ ... παρὰ / πα / σει τοι / φ θεοι φ)<sup>[25]</sup>. In this respect, the journey might be termed pilgrimage, where visitors and pilgrims physically considered the deities that they perceived, and spent some of their time to inscribe permanent records of their feelings.<sup>[26]</sup>



**Fig: 2 Graffito recording the sayings of Sansnôs**

(after, Lepsius, C., R., (1913) *Denkmäler aus Ägypten und Aethiopien*, Leipzig, Abth. VI, Band Inschriften XII, pl. 97, no. 444)

Pilgrims some other times travelled to sanctuaries for the sake of healing, performing a sort of “**Medical Tourism**”. Strabo saw testimonials written by cure-seekers who had incubated at the Serapeum of Canopus.<sup>[27]</sup> At Abydos, Osiris was often invoked as a healing deity “*I Spartakos, son of Phaidros, have come to Abydos; save me, Osiris*”.<sup>[28]</sup> Philae was also revered as a center for pilgrimage, where most of the people graffiti at the temples paid homage to goddess Isis, who was known to heal the sick during incubation.<sup>[29]</sup>

Bernands in studying collections of the Greek and Latin graffiti from Philae, found that some tourist inscriptions repeated the same epigram praising the goddess Isis and the excursion through the Nile: “*Having travelled over the great expanse of the fruitful Nile, I [... ..] have come to the great goddess Isis, making a mention for good luck on behalf of my parents [... ..]*”.<sup>[30]</sup> The repeated epigram varied in dates, the earliest dated before the reign of Ptolemy XII<sup>[31]</sup>, and the latest to the 4<sup>th</sup> century A.D.<sup>[32]</sup> Such repetition reveals tourists' curiosity about the river and the island of Philae. It might also refer to **regular scheduled tours** to the sites, where such formulae might be prepared

in advance, ready to add the names according to the tourist choices. Furthermore, as gleaned from some graffiti, tourists occasionally admired certain sites that they had repeated their visits six times.<sup>[33]</sup>

In reality, Graffiti would be considered a treasure trove for the study of tourism through many disciplines. Being scrawled on the walls at a site indicates that the site was at its height of popularity.<sup>[34]</sup> Relying on this, the Colossi of Memnon were considered among the chief goal of tourists in Thebes in Graeco-Roman times. The statues preceded the now vanished mortuary temple of Amenhetep III, and mistakenly identified with the name of the Ethiopians' king Agamemnon in Homer's *Odyssey* who was killed by Achilles in the Trojan War.<sup>[35]</sup> The northern statue, known as vocal Memnon, emitted a whistling sound at dawn, caused presumably by heated air escaping from cracks which appeared after an earthquake damaged the statue. Thus, it reminded the Greek visitors of the myth of Memnon who cried out to his mother Eos - the goddess of dawn, hence its name was granted. The content of numerous graffiti carved on the colossi's feet and legs bore witness to how they caught the interest of the Graeco-Roman tourists longed to behold them and explicitly registered that they have visited Thebes in order to hear the statue 'crying' for his mother.<sup>[36]</sup> Among the interesting graffiti are the poetic inscriptions of Caecilia Trebulla dated to AD 130, who might have been among the retinue of Empress Sabina, one of her verses reads: *"From Trebulla, Hearing the sacred voice of Memnon, I longed for thee, my mother, and desired that thou also might hear it"*.<sup>[37]</sup>

As a writing testimony of tourism practices, the use of graffiti seems continual till recent times. It may be relevant to consider here the remarks of *Jean-François Champollion*, who has noted during his voyage a wide number of graffiti, and noted that they cover most probably the activities of a variety of visitors who toured the Egyptian sites since antiquity to modern times. In describing them he states: "... Je dois cependant ajouter que plusieurs de ces tombes royales portent sur leurs parois le témoignage écrit qu'elles étaient, il y a bien de siècles, abandonnées et seulement visitées, comme de nos jours, par beaucoup de curieux désœuvrés, lesquels, comme ceux de nos jours encore, croyaient s'illustrer à jamais en griffonnant leurs noms sur les peintures et les bas-reliefs, qu'il ont ainsi défigurés. Les sots de tous les siècles y eurent de nombreux représentants ... **Egyptiens** ... qui se sont inscrits, les plus anciens en hiératique, les plus modernes en démotique; ... des **Grecs** de très ancienne date ...; de **vieux Romains** de la République; ... une foule d'inconnus du Bas Empire ...; des noms de **Coptes** ... enfin, des noms de **voyageurs européens** ...".<sup>[38]</sup>

Summing up, the most significant contribution made by all such graffiti with the diversity of their writers, dates and motivations is that they document the appreciation of the country's guests for the Egyptian marvels on which they wanted to leave a mark of their presence. They also stand as extra proof that tourism was not a new phenomenon in Egypt and that the country became a popular tourist destination for Greeks and Romans from the second half of the first millennium BCE onwards. A fact that might in its turn reflects the generous **Egyptian Hospitality** as a major promotional necessity for such a continuous desirable host destination. Particularly if we know that the ethic of hospitality echoed aloft for the Greeks and Romans, as for them it was enjoined by divine precept. In consequence the routine of welcoming, feeding, protecting and comforting a guest was of the utmost importance to them.<sup>[39]</sup> As a matter of fact, Egyptian hospitality was mentioned as early as the Homeric poems - *Iliad* and *Odyssey*<sup>[40]</sup>, where Odysseus' account of his visit to Egypt may have formed a real background recounting about the king's power and hospitality, and of the immense richness of the country.<sup>[41]</sup> For Achilles, the richness of Thebes is topped by "gifts as many as the sands".<sup>[42]</sup> Also the precious materials and the craftsmanship of the Egyptian household articles that Menelaus received as gifts from his Theban friends add to Helen's god-like appearance in front of Telemachus.<sup>[43]</sup> Further evidence of Egyptian hospitality could be observed in the intercourse of diplomatic courtesies that were exchanged between Egypt and Rome in 273 B.C., where the hospitality of Ptolemy II towards the Roman ambassadors and the magnificent gifts that they received from him were frequently reported.<sup>[44]</sup>

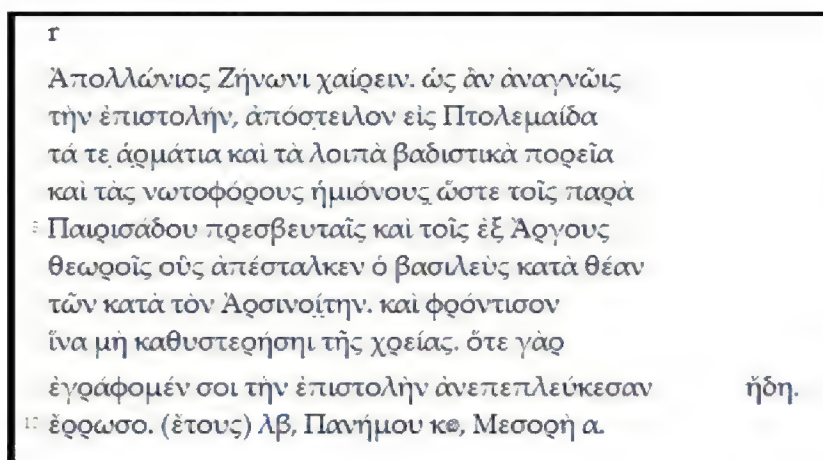
On the official context, hospitality may sometimes require advance preparations so that the visits might run smoothly. A mention of such is found in the papyri archive of Zenon, who was the estates manager and general administrator of Apollonius, the minister of Finance under King Ptolemy II. Zenon correspondence preserved for us a letter of Apollonius [Fig.3], telling him to get ready for the visit of two distinguished parties of foreigners who were coming for sightseeing tour in the region round Arsinoe (now Fayum).<sup>[45]</sup> The guests were a delegation sent by Pairisades II, king of Bosporus and the other party from Argos in mainland Greece. The letter dated Mesore 1st, 254 BC and was received and docketed by Zenon the next day at the 10th hour [Fig.4]. It seems that the whole arrangement went rapidly. The letter was thus sent so that Zenon ought to rush the carriages and mules needed for transport to Ptolemais as soon as he had read the letter. According to Westermann the recording of the time is unique in the extant correspondence of the Zenon archive, where other letters from Apollonios to Zenon are docketed only by the year, month and day.<sup>[46]</sup>

Scholars varied in their opinions concerning the unusual addition of the hour of the receipt. Some assumed that it was the result of the use of the express post<sup>[47]</sup>, others believed that it indicated Zenon compliance to his command to send the required transport immediately on receipt of the letter or that he was anxious to note the exact time of arrival in order to cover his back as the message requires transport to arrive on time.<sup>[48]</sup> Whatever Zenon's motive of such unique docketing of the time, but it might aptly emphasize that even when sudden or urgent arrangements were involved every effort was made and the utmost care was taken for providing the tourists with a satisfactory experience and good impression of their visit.

Moreover, this papyrus also highlighted the Fayum region as a thriving tourist destination famed for its attractions, of which Classical authors praised the so-called labyrinth, i.e. the pyramid-temple of Amenemhet III at Hawara from the twelfth dynasty, as well as its patron Souchos, the crocodile deity (also called Petesuchos)<sup>[49]</sup>, whose exhibition

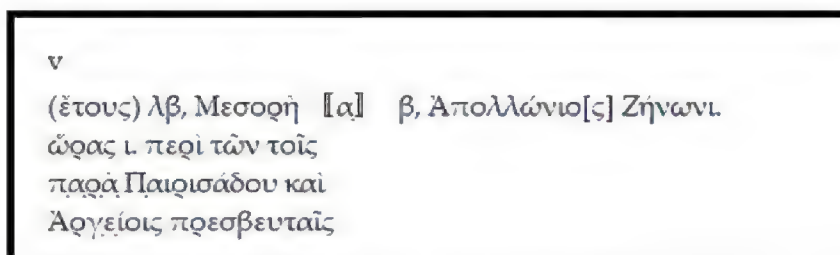


was aptly described by Strabo Stating that pilgrims accustomed to come to feed the sacred crocodiles with cakes, some meat, and drinks made with honey.<sup>[50]</sup>



**Fig: 3 P. Lond. VII 1973 (Recto)**  
**The Letter from Apollonios to Zenon in 254 BC**

*"Apollonios to Zenon, greetings. As soon as you have read this letter, send to Ptolemais the chariots, the other conveyances for the journey, and the luggage-mules for the ambassadors from Pairisades and the delegates from Argos whom the king has sent to see the sights in the Arsinoe district. Take care they are not late for when they are needed, for when I wrote this letter to you, they had already sailed up-river. Farewell. Year 32. the 26th of Panemos – the 1st of Mesore.*



**Fig: 4 P. Lond. VII 1973 (verso)**  
**The Letter from Apollonios to Zenon in 254 BC**

*Verso right: [address] Apollonios to Zenon*

*Verso left: [docket of receipt] " Year 32. The 2nd of Mesore. At the 10th hour. Concerning transport for the ambassadors from Pairisades and of Argos".*

*(Fig: 3,4 after, Llewelyn, S., R. (1994) New Documents Illustrating Early Christianity: A Review of Greek Inscriptions and Papyri Published in 1982-83, vol. 7, North Ryde, NSW: Ancient History Documentary Research Centre, Macquarie Univ., p.10 footnote, 21)*

The latter two sights were also part of the itinerary prepared for the Roman senator, Lucius Memmius, who made an official voyage to Egypt in 112 BC, as we know from a copy of a letter sent by a high official at Alexandria, to Asklepiades, the superintendent of revenues [Fig.5], announcing the approaching visit of the senator to Fayum, and giving instructions for his reception and entertainment. The copy is enclosed in a letter, (dated to 5 March 112 B.C.), from Hermias to Horos, the royal scribe, telling him to take care that its instructions are followed.<sup>[51]</sup> The letter particularly emphasizes that the senator, who was coming as a tourist, is to be attentively received everywhere; at certain places, his accommodations were to be neatly arranged rooms and it was also envisaged that the senator would be given guest-gifts at the landing stages of his lodgings. Part of the sightseeing program included the feeding of the crocodile-god Petesuchos and the other sacred crocodiles as well as visiting the so-called labyrinth. Provisions were also to be made for votive offerings and the performance of a sacrifice.<sup>[52]</sup>

Memmius is often cited as an early example of Roman tourism in Egypt.<sup>[53]</sup> As a matter of fact, he might be the only one-recorded explicitly as a tourist of the thousands that must have flocked to Egypt at all times "to see the sights," but he stands, as all other evidences, for that Egypt had always been the land of wonders. The diversity of its attractions and generosity of its hospitality enabled it to stand in the ranks of the major tourist destinations in the

ancient world. From this point and through the previous survey, one might postulate that the tourism activity in Egypt have maintained a consistency over the Graeco-Roman period. *The question arises as to whether developing relationships and creating a cultural syncretism were the sole objectives of tourism at that time, or that there were other driving forces in parallel with that in so far as it can foster some ulterior interests of the Greeks and the Romans?*

	Ἑρμ Ὡρωι χαίρειν). τῆς πρὸς Ἀσκλη(πιάδην) ἐπισ(τολῆς) ἀντίγρ (αφον) ὑπόκι(ται).
	[φρόν]τισον οὖν ἵνα γένη(ται) ἀκολούθως. ἔρρω(σο). [(ἔτους)] 5
	Ξαντικοῦ 17 Μεχείρ 17.
	Ἀσκλη(πιάδει). Λεύκιος Μέμμιος Ρωμαῖος τῶν ἀπὸ
	συνκλητῶν ἐν μείζονι ἀξιώματι κα[ι] τιμῇ
5	κεῖμενος τὸν ἐκ τῆς πτό(Λεως) ἀνάπλουν ἕως τοῦ Ἀρσι(νοίτου) νο(μοῦ)
	ἐπὶ θεωρίαν ποιούμενος μεγαλοπρεπέστερον
	ἐγδεχθήτω, καὶ φρόντισον ὥς ἐπὶ τῶν
	καθηκόντων τόπων αἱ τε αὐλαὶ κατασκευαῖς-
	[θ]ή[ς]?[ο]ν?ται καὶ αἱ ἀπ?ο? τούτων ἐγβα(τηρία) ε?[,]ι?ε? [...]
10	π?.... συντελεσθήσονται καὶ αὐτῶι πρὸς-
	ενεχ?θ?ήσε?ται ἐπὶ τῆς ἐγβατηρίας τὰ ὑπογεγραμμένα ξένια,
	καὶ τ[ὰ] εἰς τὸν τῆς αὐλῆς καταρτισμὸν
	καὶ τὸ γεινόμενον τῶι Πετεςούχῳ καὶ τοῖς κροκο(δείλοις)
	ψω?μ?ί?ον κ?α?ι? τὰ πρὸς τὴν τοῦ λαβυρίνθου θέαν
15	καὶ τ[ὰ] [...]ταθησόμενα θύματα καὶ τῆς
	θ?υ?ς?ι?[α]ς? ἡ? π?α?ρ?ο?χῆ? ο?ι?κ?ο?ν?[όμη]ται, τὸ δ' ὅλον ἐ?π?ι? π?
	ἀ?ν?[των]
	τὴν μέγιστην φροντίδα ποιούμενος τοῦ εὐδοκοῦν[τ]α?
	τὸν ἀ?ν?δ?ρ?α? κατασταθῆ[ναι] τὴν πᾶσαν προσενέγκαι
	σπουδῇ[ν] ...τε[.].στ?[.....]...μ?ο?
20	Λ?..ης[.].α?..[.].η?..δα[.].[.....] ]ν?
	τ?η?ς?τ[...].ε?ι?κ?α?..[....]π?ο?μ.[ @αξ. ]
	[.....] ]υ?ε?.[ @αξ. ]
	[.....] ]ι?..τ?..ρ?..τ?.[ @αξ. ]
	[.....] ]ἀρτο?ι?.[ @αξ. ]
25	[.....]καται λ λ? [ @αξ. ]

**Fig: 5 P. Tebt. I. 33**  
**The Roman Senator visit in 112 BC**

"Hermias to Horos, greetings. Appended is a copy of the letter to Ahclepiadesd. Take care that its instructions are followed. Farewell. 5th Year 5. The 17th of Xandikos – the 17th of Mecheir. To Asklepiades: Lucius Memmius, a Roman senator who is regarded with much respect and honour, is journeying up-river from the city [Alexandria] to the Arsinoe district to do some sightseeing. Let him be received with special magnificence, and take care that at all the proper spots the guest-rooms be prepared and the landing-places there be got ready, and that at the landing-place the under-mentioned gifts of hospitality will be presented to him. Take care that the preparation of the guest-room, the customary tit-bits for Petesouchos and the crocodiles, and the necessaries for the view of the Labyrinth, and the offerings and sacrifices be provided; in general. Generally in every respect take the utmost care to see that the visitor may be satisfied and make every effort ....."

(after, Wilhelm, A. (1937) JRS 27, Part 1, pp. 145-151.)

If we meditate deeply into some of the aforementioned examples, it may seem that tourism brings only benefits, but further consideration shows that it may also have a darker side. In other words, the seemingly objective of tourism is sometimes considered an accessory to the crimes committed by empires in the name of civilization.

It was as early as the end of the eighth century BC that Egypt had reached the horizon of the Greek speaking world.<sup>[54]</sup> References to Egypt occur in almost every classical author to the extent that it gained a peculiar position in the imaginations of the Greeks and Romans. It stimulated their interest to see the land of enormous antiquity, the land of ancient wisdom, and most of all the land full of wonders: natural ones, such as the Nile River, and even more impressive man-made ones, such as the pyramids. In other words, they came to see Egypt of their classical

literatures comes to life. One of the paradoxes of ancient tourism, referring for example to the aforementioned colossi of Memnon, is that the Greek and Roman tourists identified Homer, who barely touched upon Egypt in a few lines of the Iliad and Odyssey; which means that they were occasionally seeking out the sites of Egypt known from Homer, whose works were the basis of their education.

As a matter of fact, such encouraging factors not only motivated the general public to exploit Egypt, but on the other side of the spectrum, it also alerted the avidities and aspirations of politicians and the military leaders. Consider the case of Alexander the Great, when he set off to conquer Egypt. No doubt he was influenced to some extent by Homer. Far as we know that Alexander was fond of all kinds of learning and reading but his attachment to Homer surpassed them all, that he constantly laid Homer's Iliad with his dagger under his pillow<sup>[55]</sup>, declaring that he esteemed it a perfect portable treasure of all military virtue and knowledge.

From this standpoint, we can say that the arrival of Alexander the Great to conquer Egypt was the result of his awareness of its characteristics and its resources through his literary readings, as well as other means as it is necessary for the colonizer to get some picture of the enemy and his vast territory.<sup>[56]</sup> According to Plutarch, before Alexander set off to conquer the vast Persian Empire, he had interrogated some visiting Persian ambassadors about the lengths of the roads and the nature of the route to the interior of Persia, what sort of a warrior the Great King was, and what was the strength and power of the Persians.<sup>[57]</sup>

Aeneas Tacticus, the Greek military writer, towards the middle of the fourth century B.C., vividly expressed in his *Poliorketika*, or *"How To Survive Under Siege"*, the importance of what is now known as Military Intelligence, when he was advising how in defensive warfare one must make the maximum use of a superior knowledge of the geography of one's own country: *You should always make your attacks upon the enemy with an advantage from your familiarity with the terrain, for you will have a great superiority from knowing the ground beforehand.... For there would be as great a difference between the two sides as if one happened to fight by night, and the other by day, if it were in any way possible that this should happen simultaneously.*<sup>[58]</sup>

However, an interesting parallel in the Roman world is found in Julius Caesar's first expedition to the little-known island of Britain in 55 B.C., when he was faced with a special problem; that there were no Roman ambassadors there, and apparently no written works that described the island, except some brief description. His first expedition, then, was to be a reconnaissance: *"...Even if the time should be insufficient for waging war, he still thought it would be of great advantage to him, if he only went to the island, and saw into the character of the people, and got knowledge of the places, harbours, and approaches. Practically all of these were unknown. For neither does anyone except merchants easily go there, nor is any portion of it known even to them, except the sea-coast and those parts opposite to Gaul. So, he summoned the merchants from all parts, but he could learn neither the size of the island, nor the names and populations of the nations which inhabited it, nor what system of war they followed, nor what customs they used, nor what harbour were suitable for a large number of ships...."*<sup>[59]</sup>

It has been observed through the above details that the use of embassies as informers or for spying was notorious in antiquity. Moreover, Richmond in his study of spies in ancient Greece<sup>[60]</sup>, states that *much of the evidence about them comes from the precautions to be taken against them as prescribed by Greek military writers. Elaborate security precautions had to be put in place.* Quoting Aeneas Tacticus<sup>[61]</sup>, who gives a long series of precautionary measures to be adopted on the outbreak of war or to secure against treachery; Richmond listed those which might especially affect spies, of which I only cite whatever point to any of the aforementioned tourism activities:

- 2. *No festivals are to be held outside the city.*
- 5. *No common feasts to be held except for weddings and funerals, and for them notice is to be given to the authorities.*
- 11. *Restrictions on mooring of ships. [This was to prevent illegal landing or boarding by spies, or surprise attacks from the ships.]*
- 13. *Aliens to be lodged only with state permission and registers to be kept of their abodes. The authorities are to lock them in at night. Vagrants are to be expelled; foreign students and others to be registered.*
- 14. *Restrictions on access to foreign ambassadors.*
- 17. *Curfew regulations.*

It seems remarkable that all these measures checked the infiltration of spies during certain practices mostly related with tourism activities or events, i.e. the attendance at religious festivals, feasts and any other sorts of social contacts that might provide both opportunities to gain information and cover for spies.

Scholar in studying Political Intelligence in Classical times found out that, roaming ambassadors and other sorts of travellers would be a weighty source of information, whether actually on sightseeing tours or as infiltrated spies.<sup>[62]</sup>

Dwelling on that, one might believe that some of the Egyptian sites were frequented because of their strategic importance. In this regard, such several visits to the region of Fayum might in its external face seem strengthening the bonds of affection and friendship, while in its internal have hide a vested interest of spying on the ancient Egyptian resources of wealth and richness, and explore the conditions of the country and the people, directly (eye view), and not through narrations of travellers and ancient historians. Worth mentioning, the economical and agricultural wealth of the Fayum region, where the great engineering project of Ptolemy Philadelphus for reclamation of land was in full swing mostly as a model of a productive Egyptian village in Greco-Roman times<sup>[63]</sup>. As for the Romans, the province of Egypt was simply a land "to be exploited methodically and efficiently".<sup>[64]</sup>

In this regard, Th. Walek believes that the negotiations of 273 B.C. had an important bearing on the commercial interests of Egypt.<sup>[65]</sup> The Romans wished to stand well with the sovereign who controlled "the richest corn market in the world"<sup>[66]</sup>. Therefore foreign envoys may well have used their official titles to serve ulterior motives, such as negotiating for a grain supplier, or scouting around for an investor in an entrepreneurial scheme. They could meet with officials while attending Ptolemaic festivals or announcing festivals back home, thereby enlarging their circle of contacts, and above all being sent as observers.

### Conclusion:

We might have elicited only a shadowy picture of such hidden face of tourism but it showed that either intended or inadvertently tourism might become one of the most important tools for surveillance and espionage during the Graeco-Roman period. Summing up, it would be now reasonable, from all the above details, to agree that tourism as a phenomenon in Graeco-Roman Egypt was like a two-sided coin; its bright side is found in its positive force in developing relationships and promoting cultural understanding between nations; while its dark side stands for its casual use as a vehicle for inhibiting peace and internal immunity that resulted in the colonization of Egypt for successive centuries.

### Notes:

1. Matthews R., Roemer C. (2003), p.13.
2. The most famous Classical sources: Herodotus (*Histories*, London: 1912); Diodorus Siculus (*Library of History*, translated by C. H. Oldfather, London: 1946, Loeb ed.); Strabo (*The Geography of Strabo*, trans. H. L., Jones, London: 1949, Loeb ed.); Plutarch (*Plutarch's De Iside et Osiride*, ed. J. Gwyn Griffiths, Univ. of Wales Press: 1970).
3. Herodotus, II, 35.
4. Herodotus, II, 143; Casson L. (1974), p. 97.
5. Diodorus Siculus, I, (36.7); (63.3); (69.1-7); (83.1); and (91. 1, 4). In his book I,9. 6, he mentioned that Egypt is the first nation studied in his history because of the noteworthy deeds of its great men.
6. Strabo, I, 2. 29-30.
7. Strabo, XVII, 1.
8. Plutarch, *De Iside et Osiride*, 354 D-E; See: Griffiths J. G. (1970), p. 17
9. This definition introduced by Swiss Professors, Hunziker and Krapf, and adopted by the international Association of Scientific Experts on Tourism (IASET). See: Seth P. N. (2008), p.5; See also WTO (1995), UNWTO technical manual No 2, p.14.
10. Rickman G. (1980), pp. 12-13, 61, 67-71.
11. 'The Greatest Emporium of the Inhabited World', such phrasing was Strabo's description of Alexandria, the Egyptian capital, after he witnessed its flourishing trade activity. See: Strabo, XVII, I. 13.
12. Seth P. N. (2008), pp. 4-6; Ogilvie F. W. (1934), p. 661. Ogilvie added that the term tourist as a synonym for traveler became current since early in the nineteenth century.
13. Momigliano A. (1966), p. 129.
14. Sites in Herodotus books II and III arranged respectively as sited above as follows: II, 2-3; II, 3, 54, 91, 143; II, 28, 130-1, 169-70, 175; II, 29; II, 75, 155; II, 125ff; II, 3, 73; II, 148-9; and III, 12.
15. Strabo, XVII, 1. 33, 42, 46.
16. P. London, III.854; Mitteis L., Wilcken U. (1912), no. 117.
17. Milne Grafton J. (1916), *JEA* 3, p.79.
18. Milligan G. (1969), pp. 69-70.
19. Herodotus, II, 28.
20. Strabo, XVII, 1. 42,43. In Greek, Ammon or better still, Zeus-Ammon
21. Amun's most illustrious visitor was Alexander the Great, who went to legitimize his divine parentage. The oracle was active there into Justinian period, see: Wagner G. (1987), *IFAO* 100, p.331.
22. Sheehan L. et al (2007), *Journal of Travel Research* 46.1, pp. 64-74.
23. Geraci G. (1971), *Aegyptus* 51, pp. 16 – 20.
24. Mitteis L., Wilcken U. (1912), no. 116; Frankfurter D. (1998), *Religions in the Graeco-Roman World*, Vol.134, p. 85.
25. Bataille A. (1939), *BIFAO* 38, p. 145.
26. Montserrat D., Meskell L., (1997), *JEA* 83, p. 183.
27. Strabo, XVII, 1. 17
28. Perdrizet P., Lefebvre G. (1919), Abydos nos. 390, 414, 426
29. Diodorus I. 25. 3-5
30. Bernand A. (1969); Bernand E. (1969).
31. Bernand A. (1969), no. 43.
32. Bernand E. (1969), no. 151.
33. Perdrizet P., Lefebvre G. (1919), Abydos no. 227.
34. Casson L. (1974), pp. 33, 274 and 260f.
35. Homer, *Odyssey*, IV.188, XI.522; Gardiner A. (1961), *JEA* 47, pp. 91-99.



36. Bernand A., Bernand, E. (1960), IFAO, pp. 92-94, 187-191; Letronne A. J. (1833), pp. 34f.
37. Rosenmeyer P. A. (2004), *The Classical Quarterly*, 54:2:620-624; Plant I. M. (2004), chapter 42 entitled: Caecilia Trebulla (fl. C. AD. 130), pp. 148f.
38. Ch. Desroches - Noblecourt, (1972), vol.II, pp. 151-152, quoting letters written from Egypt and Nubia in 1828-29.
39. Gauthier P. (1973), *Ancient Society* 4, pp. 1-21
40. For detailed discussion see: Reece S. (1993).
41. Homer, *Odyssey*, XI V.257ff; Matthews R., Roemer C. (2003), p.13.
42. Homer, *Iliad*, IX.381-385; cf. *Odyssey* IV.126-127.
43. Homer, *Odyssey*, IV.120-137.
44. Neatby L.H. (1950), *Transactions & Proceedings of the American Philological Association* 81, p.89.
45. *P. Lond.* VII 1973; Rostovtzeff M. (1928), *JEA* 14, No. 1/2, p. 13
46. Westermann W. L. (1928), *Political Science Quarterly* 43, pp. 364-387.
47. Westermann W. L. (1928), *Political Science Quarterly* 43, pp. 376ff.
48. Llewelyn S. R. (1993), *ZPE* 99, pp. 48f, see also footnote 20.
49. Herodotus, II. 148-9; Diodorus, I. 61.2; Strabo, XVII.1.35, 37.
50. Strabo, XVII, 1, 38; Graves R. (1968), p.45.
51. P.Teb.I.33; Wilhelm A. (1937), *JRS* 27, Part 1, pp. 145-151; Sonnabend H. (1986), pp. 23, 121.
52. Hölbl G. (2001), pp 10-11.
53. Sonnabend H. (1986), p. 121; Milne Grafton J. (1916), *JEA* 3, p. 78.
54. Matthews R., Roemer C. (2003), p.13.
55. Plutarch, *Life of Alexander*, 8.1,2 and 26.1- 4.
56. A Correspondent (1927), The author discusses that the motive of Alexander's visit to the oracle of Ammon was military
57. Plutarch, *Life of Alexander*, 5.1.
58. Richmond J. A. (1998), *Greece & Rome*, Second Series, Vol. 45, No. 1, pp. 1-18. He quoted Aeneas Tacticus, *Poliorketika*, 16.19-20.
59. Caesar, *The Gallic War*, IV. 20-1.
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61. Aeneas Tacticus, *Poliorketika*, 10.2-26.
62. Starr, C. G. (1974), *Mnemosyne Suppl.*, Vol. 31, pp. 22-24.
63. Bevan E. (1927), p. 114; Rostovtzeff M. (1922), *University of Wisconsin Studies in the Social Sciences and History* VI, pp. 56-92
64. Reinhold M. (1980), *Ancient World* 3, (1980), pp 97-103. To Strabo, this nome was 'the most noteworthy with respect to appearance, fertility, and material development'. See: Strabo, XVII, 1.53.
65. Walek Th. (1925), *Rev. Phil.* 49, p. 137.
66. Holleaux M. (1921), , *École Française d'Athènes et de Rome*, p. 77.

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